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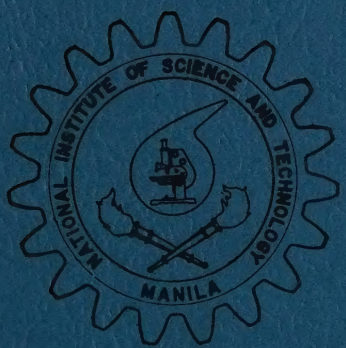

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THE PHILIPPINE
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NEW OR LITTLE-KNOWN TIPULIDÆ FROM EASTERN ASIA (DIPTERA), XLIX

By CHARLES P. ALEXANDER
Amherst, Massachusetts

SIX PLATES

In the present report I am considering a small part of the rich collections of crane flies that have been taken in various parts of India by Dr. Fernand Schmid. I am very deeply indebted to Dr. Schmid for his continued interest in collecting these fragile flies. His materials from various parts of the Himalaya, particularly from Kumaon and Sikkim, are very rich in species and have quite revolutionized our previous knowledge of the crane flies of India. In order to more properly introduce the subject I have provided a somewhat detailed preliminary statement discussing the collections that have been made in the past, together with some further correlated matters.

DEVELOPMENT OF OUR KNOWLEDGE OF INDIAN CRANE FLIES

In other papers in the Philippine Journal of Science I have presented accounts covering this same general heading for Japan[1] and for New Guinea.[2] In beginning a consideration of the crane flies found within the geographical limits of the former "British India" it seems desirable to furnish a somewhat comparable discussion covering this part of southern Asia. As now constituted, this area includes various independent

[1] Philip. Jour. Sci. 82 (1953) 21–33.
[2] *Ibid.* 89 (1960) 221–274.

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nations and republics within the framework of the British Commonwealth—Pakistan, India, Ceylon and Burma, as well as the small Himalayan monarchy of Nepal. I am treating this subject under the following subheadings: (*1*) Geographical considerations, (*2*) Enrico Brunetti, and (*3*) Crane-fly collections.

GEOGRAPHICAL CONSIDERATIONS

In the vast area here considered particular interest applies to the great mountain system that forms the northern boundary, the Himalaya. A majority of the crane flies known from the entire region occur on the southern slopes of the Himalaya, representing the Oriental fauna at the lower levels, the Palæarctic at higher altitudes, as discussed later in this account. The isolated so-called "Hills" of the western Ghats in south India, chiefly in the states of Mysore, Madras and Kerala, support a most interesting fauna. Ceylon likewise has a rich crane-fly fauna, including in part certain widespread elements but with many endemic species at the higher levels. Assam, south of the Brahmaputra River, has several mountainous areas, including the Garo, Khasi, Naga and other hills, all with an exceedingly rich crane-fly fauna. To about 5,000 feet these hills in Assam are subtropical, with strong Malayan affinities, while above 6,000 feet the fauna is definitely Indo-Chinese. Burma, particularly in the high mountains of the north-east, is exceedingly rich in crane flies, including many Chinese elements.

The Himalaya.—This vast mountain system constitutes an effective barrier to the north-south distribution of many types of plants and animals. The exact limits of the Himalaya remain in question, not so much perhaps to the geographer or the geologist as to the biologist. Hingston (1920) considers the Himalaya as comprising a mountain system composed of many ranges whose terminations are unknown. The southern and northern boundaries, the plains of India on the one hand, the lofty Tibetan plateau and the Pamirs on the other, are more apparent but the east-west limits remain in question. Formerly it was believed that the Indus River on the west and the Brahmaputra on the east delimited the Himalaya but more recent knowledge shows that such a simple explanation is improbable. In the west the system merges with the high mountains north of Afghanistan while in the east it passes into the region of northern Burma and the borderland of China. The distinguished botanist and plant collector, the late F. Kingdon Ward, conducted several expeditions to this disputed area of

the eastern Himalaya and summarized his personal beliefs as they concerned the eastern extent of the system. Three works by Ward, cited in the list of "References" following this general account, are of particular interest in this connection. The eastern end of the Himalaya trends roughly east-northeast, culminating in the high peak, Namcha Barwa, altitude 25,445 feet. Beyond this point the mountains appear to trend southwestwards through Burma and thence eastward into Java, forming the loop known as the Malay Arc. Ward [(1934) 12] believes that insofar as distribution of plants and animals is concerned that the more ancient Altaid system of mountains carried the biota eastward across China. These latter mountains were in existence before the present Himalayan system came into being and it appears that the existing mountains are not primary ranges but merely southward projecting spurs from this more ancient system. The main axis of the Himalaya may be traced by the high peaks of these spurs. Ward calls attention to the fact that the relationship of the mountain flora of this part of Asia shows a preponderance of an east-and-west over a north-and-south relationship, despite the evident advantage of the latter during the periods of glaciation in recent geological times. He notes that the east and west continuity of the flora was scarcely impaired by this glaciation, seeming to indicate the presence of great mountain ranges trending east and west that permitted the flora to spread in either of these directions. He writes [(1934) 15] "Recent botanical exploration has shown the affinity of the eastern Himalaya flora lies mainly with western China, across the river gorge country, and not with the Indo-Malayan mountain system. This fact is most simply explained by the existence of a former Himalayan range stretching eastwards into China." From a long-time study of the crane flies of western China I subscribe to this explanation and belief. It would appear that many Himalayan elements have extended their range far to the east, even to Formosa, as was discussed in a significant paper by Gressitt (1936), explaining in part the striking differences in fauna and flora existing between Formosa and northern Luzon.

Limits of the Oriental Region.—The whole of lowland India, Ceylon and Burma is Oriental, with Palæarctic elements appearing only at relatively high altitudes in the Himalaya. In the northwestern section of the latter, as Pakistan and Kashmir,

the delimiting line between the two regions evidently lies much lower than is the case farther to the east, where the range has trended more to the south, reaching an approximate latitude of 27° north in West Bengal, Nepal, and Sikkim. Thus in Kashmir, Palæarctic elements are found even at 5,000 to 6,000 feet. Annandale [in Burnetti (1917) 59] placed the line at Simla in the western Himalaya at approximately 7,000 feet or even lower. Mani and Kapur (consult references) in the Panjab Himalaya found nearly the same figure. Edwards [(1928) 682] in Sikkim and adjoining Tibet found Oriental elements as high as 10,000 or even to 12,000 feet. Based on Schmid's extensive materials taken in 1959 in Sikkim, Palæarctic types of crane flies were common at about 9,000 feet and predominant at 10,000 feet and above. At approximately 12,000 feet, in the *Rhododendron* association, a characteristic crane fly fauna was found. It may be noted that here Schmid found a species of crane fly, a *Tipula* of the subgenus *Bellardina*, at 17,000 feet, representing the highest altitude in the Old World at which these flies have been taken.

Mani, Kapur and Santokh Singh (References, 1954–1958) call attention to the fact that in the Panjab Himalaya myriads of dead insects of small size may be found on the snows at about 14,000 to 16,000 feet, or even to 20,000 feet, having been carried upward from the lower plains by winds and convection currents. As regards living insects at high altitudes, Mani [(1955) 157, diagram 167] indicates that the abundance of insect life falls off rapidly beyond the limits of tree growth (between 10,000 and 12,000 feet) but that the zone of perpetual snows immediately above these limits is by no means barren of insect life. Kapur (1958), likewise in the Panjab Himalaya, notes that between 8,000 and 15,000 feet, the genera occurring mostly are of Palæarctic types, rarely showing Oriental affinities. He notes that above about 8,000 feet there is a progressive reduction in the number of species of insects, correlated with the reduction in vegetation and the increasing severity of climate but even at 15,000 feet or thereabouts there still is life in various ecological niches having a favorable microclimate.

ENRICO BRUNETTI

Of all early workers on the Indian crane flies, Enrico Brunetti described the largest number of species and exerted the greatest influence on the development of our knowledge of the

subject. Because of this importance a brief account of him and his work is provided.

Brunetti was born in London, England, May 21, 1862, his father being Italian, his mother English. He followed the profession of musician and orchestral leader, coming to India in 1904 as a band conductor, travelling not only in parts of India but in other sections of the Far East, including Java and the Treaty Ports of China. After 1906 he remained in India, chiefly in Calcutta, taking occasional short collecting trips into the hill stations, as discussed elsewhere in this account. On such excursions he collected many insects, stressing particularly the Diptera, in which order he seems to have become interested through his early association with George Henry Verrall (1848–1911) in England, and later with Thomas Nelson Annandale (1876–1924) in India.

Despite his lack of formal training and prior experience in the order he almost at once began the work of revising the Oriental Diptera. Doctor Annandale offered him the facilities of the Indian Museum and for part of the time he was a staff member while at other times his work was gratuitous and it was during these periods that he was able to build up his personal collection of Diptera. He became associated with the Zoological section of the Museum in 1904 and with the Zoological Survey of India at its founding in 1916. About 1920 it became advisable for him to visit England and the British Museum, primarily to compare certain of his Indian materials with the extensive collections in London. He left for England in May, 1921, originally intending to be away only for about a year but, as events transpired, he did not return to India during the remaining six years of his existence. For his studies in England he took with him not only his personal series of Diptera but also certain types from the Indian Museum collection. It was extremely fortunate that comparisons of specimens could be made with the constant advice and cooperation of Doctor Fred W. Edwards, then in charge of the Diptera collections of the Museum and one of the great students of the Nematocerous Diptera, including the Tipulidæ. The results of this survey by the two leading students of Indian crane flies has been summarized in an important paper by Edwards (1924). Brunetti died in London on January 21, 1927, bequeathing to the British Museum (Natural History) not only his library but also his personal collection of Diptera, totalling

some 80,000 specimens. The remainder of the Diptera that he described, including the majority of the type specimens in the Tipulidæ, are in the Indian Museum, Calcutta.

Biographical notices concerning Brunetti have been prepared by Prashad (1927), Senior-White (1927), Alexander (1942), and some others. There can be no question that when Brunetti began his studies on the Oriental Diptera in 1905 virtual chaos existed and that when he left India only sixteen years later a firm basis and approach to order had been effected, largely through his unaided efforts. When his work began, the collections of the Indian Museum entirely lacked type specimens or even authentically named material in most groups while the amount of available unnamed specimens in the order was very limited. Despite this discouraging prospect Brunetti undertook the task with optimism and enthusiasm. Revisions and eventually monographic treatments on various families or groups of Diptera appeared at frequent intervals, culminating in the three outstanding volumes of the "Fauna of British India" series, the first (1912) including the basic treatment of the Indian Tipulidæ.

From a detailed study of his papers it is readily apparent that some parts of his work, particularly those concerned with description and cataloguing, are of high caliber, in fact, are quite remarkable considering the handicaps of material and literature that he faced. His most serious defect was his demonstrated inability to place many of his species in its proper genus, this resulting in a confused and uncertain synonymy that holds in the Tipulidæ, Mycetophilidæ, and in various other families.

Brunetti published almost fifty papers and volumes on the Diptera. In these he described some 250 species of Tipulidæ and related groups commonly designated by the term "crane fly." A paper by the present writer, still in press (1960), has listed the Brunetti species, placed each in what appears to be its correct genus, and indicated the synonymy.

CRANE FLY COLLECTIONS

The Indian fauna and flora are vastly rich. As it concerns the insects, the number of described and possibly existing species has been variously estimated. The most exaggerated figure seems to have been that given by Mohamed Afzal Hussain, in his Presidential address to the entomological section

of the Science Congress meeting in Calcutta in 1938. It was his belief that while only about 40,000 species of insects actually had been identified and recorded from India that the number of existing forms could scarcely be fewer than 2,500,000, or approximately three times the number of described insects known at the present time in the entire world! This figure of possibilities seems vastly exaggerated but any further estimate would be guesswork only. To this date only about 600 species of crane flies have been described from the region, including a number still in the press but there is no question that this is only a fraction of the number of species actually occurring.

The earliest known species of Indian Tipulidæ were described by Fabricius, Wiedemann, Macquart, Walker, Westwood, and some others. A few scattered and desultory collections were made in the period before Brunetti, the more important being from Ceylon, taken by Humbert in 1859, Felder, 1861, Yerbury, 1890, and others. The distinguished student of the Coccidæ, Mr. E. E. Green, collected specimens of Tipulidæ as early as 1888. Between 1900 and 1910, Green, Mr. T. Bainbrigge Fletcher, and Nelson Annandale collected materials in many places in British India. With the arrival in India of Brunetti in 1904 there was a marked increase in interest and collecting activity in the Diptera.

The Brunettian period.—Brunetti collected chiefly at Darjeeling (Darjiling) in the eastern Himalaya, his first excursion being in 1905, with various later trips. Other collectors of Diptera in this period include Annandale (Himalaya, from 1906; Dawna Hills, Burma, 1908; South India, 1908, 1909); H. L. Andrewes (Nilgiri Hills, 1910, 1911); William Beebe in 1910; Lord Carmichael, Governor of Bengal, with his native assistants, 1912, 1913 (when he discovered one of the world's most beautiful and striking crane flies, *Ctenacroscelis carmichaeli* Brunetti); Fletcher in South India and the Himalaya; F. H. Gravely (Dawna Hills, 1911; Satara District, 1912; Cochin, South India, 1914; eastern Himalaya, 1914–1916); F. M. Howlett (Himalaya, 1908, 1909); A. D. Imms, while at Muir Central College, Allahabad (Garhwal, 1909, 1910); Stanley Kemp, with Mrs. Kemp (very important collections, Abor Hills, 1911, 1912; Khasi Hills, 1914, 1915; Goa and North Kanara Districts, south India, 1916; Garo Hills, 1917; Darjeeling District, 1917); C. Paiva (Darjeeling, 1909).

Post-Brunettian collections.—The materials described by Edwards for the most part had been collected incidentally by hunters and plant collectors or by scientists of the various Mount Everest expeditions. The chief of these were H. L. Walton, 1904; J. W. Gregory, 1922; A. E. Hobson; R. W. G. Hingston, 1924; F. Kingdon Ward, 1924 and later. Edwards honored all of these men by dedicating to them a species of *Tipula,* subgenus *Bellardina,* including five of the most striking crane flies in the Himalayan fauna. On later trips to northern Burma and adjoining parts of Tibet, Ward was accompanied by Lord Cranbrook (in 1931) and by Ronald Kaulback (in 1933 and later), who aided materially in insect collecting (Ward, 1934, 1937). F. M. Bailey secured some interesting species in Tibet in 1927.

Ronald Senior-White made collections in Ceylon over a period of years, with further materials in the Khasi Hills in October, 1920, in company with Fletcher. His collection of Diptera is in the British Museum. The largest and most important series of insects that have been taken in South India are by Mr. P. Susai Nathan, veteran entomologist and professional collector, who between 1928 and the present date has travelled widely in most of the mountain ranges in South India, including the Anaimalai (Anamalai), Bababuddin, Malabar, Nilgiri, Palni (Pulney) and Shevaroy Hills, as well as elsewhere in south and central India. His crane-fly materials are rich in species and of great importance. During the 1930's and 1940's desultory collecting was done in Assam, chiefly in the Khasi and Naga Hills, by Mr. S. Sircar and his assistants.

In 1934, a Swedish expedition conducted by Dr. René Malaise, with Mrs. Malaise, visited various parts of Burma and brought back very large collections, including Tipulidæ, the most interesting being from the Southern Shan States and especially from northern Burma, chiefly in the vicinity of Kambaiti at 7,000 feet. The collections are in the Naturhistoriska Riksmuseet, Stockholm. Also in 1934, Miss Vivien Hutchinson, of Elloughton, Yorkshire, England, made very interesting collections in various parts of Kashmir.

The Mani-Kapur-Santokh Singh expeditions to the Northwest Himalaya (Panjab Himalaya) in 1954, 1955, and 1956 brought back a considerable series of high altitude insects, including a small number of Tipulidæ. These expeditions are described in comprehensive accounts by Mani (1954, 1955a,

1955b, 1956), Mani and Santokh Singh (1955, 1957) and Kapur (1958), all cited under the References. These materials are preserved in the Indian Museum, Calcutta. An important collection of insects was made in Nepal by Dr. Edward I. Coher and assistants, while working with the World Health Organization, in 1956 and 1957. The crane flies are in my personal collection. The Reverend Aloysius Camilleri, S.J., secured a small number of Tipulidæ in the Darjeeling District in 1958, chiefly in the vicinity of Saint Mary's College, Kurseong.

The Swiss Zoological Expeditions to India, 1953–1954; 1958–1960. The largest and most representative collections in certain groups of insects, including the Tipulidæ, ever to be taken in India were secured by the entomologist, Dr. Fernand Schmid, of Lausanne, Switzerland. The materials in the Tipulidæ are so rich in species as to virtually have revolutionized our previous knowledge of the subject. Through the kindness of Dr. Schmid the crane flies are preserved in my personal collection. The various summers were spent in different sections of the Himalaya, the intervening winters in the south of India and in Ceylon. Chronologically, the sections where Dr. Schmid collected were Kashmir, Pakistan and Baluchistan, May 28 to November 28, 1953; Ceylon, January 7 to March 18, 1954; Kumaon, in the western Himalaya (Dehra Dun, Almora, Pauri Garhwal, Teri Garhwal), March 25 to October 13, 1958; South India (Madhya Pradesh, Bombay, Mysore, Madras, Kerala), November 3, 1958 to February 8, 1959; Sikkim and West Bengal, in the eastern Himalaya, March 11 to October 17, 1959; winter of 1959 to 1960, Assam (Khasia); summer of 1960, various parts of Assam. Dr. Fred Keiser, of the Natural History Museum, Basel, Switzerland, with Mrs. Keiser, made important collections in Ceylon in 1953 to 1954, the materials being preserved at Basel.

In concluding this account it seems appropriate to add two quotations from the works of outstanding botanists, Dr. Joseph Dalton Hooker and F. Kingdon Ward, as they concern the occurrence of crane flies in the Himalaya. The first is from Hooker's "Himalayan Journals," based on an observation made in May, 1849 in the Lachen–Lachoong valley, Chakoong, Sikkim. [Hooker 2 (1854) 18]. "As the rains advanced, insects seemed to be called into existence in countless swarms; large and small moths, cock-chafers, glow-worms, and cockroaches, made my tent a Noah's ark by night, when the candle was burning;

together with winged ants, May-flies, flying earwigs, and many beetles, while a very large species of *Tipula* (daddy-long-legs) swept its long legs across my face as I wrote my journal, or plotted off my map. After retiring to rest and putting out the light, they gradually departed, except a few which could not find the way out, and remained to disturb my slumbers."

The second observation is from Ward [(1937) 239, 240], made in the Adung Valley, northern Burma, in 1931. "We had better luck with a 'daddy-long-legs', which occurred in great numbers and extraordinary diversity, varying from gigantic insects, with a wing span of six inches, to a queer alpine insect, found in the scrub rhododendron at 14,000 feet, one sex of which flies, while its mate, having only rudimentary wings, has to crawl. We caught many of these Tipulidæ, nearly all of which proved to be previously unknown. They came into the hut after dark, attracted by the light, especially on rainy nights, which suggested a certain wisdom. It must have been miserable flitting about in the Adung valley at night when the air was thick with fine mist, as it so often was."

Parts of the above mentioned crane fly materials were studied by Edwards; following his death in November, 1940, the remainder were sent to me for further study and naming. Concerning the identity of the two species above mentioned, a paper by the writer may be consulted [Alexander (1951) 1073.]

TIPULINÆ

MACGREGOROMYIA SIKKIMENSIS sp. nov.

Mesonotal præscutum buffy yellow, the disk with three brown stripes; pleura yellow, patterned with brown; antennæ with basal three segments light yellow, remainder black; legs dark brown, femoral bases restrictedly yellow; wings weakly tinged with yellow, prearcular and costal fields darker; a restricted dark pattern, especially on anterior cord, outer end of cell R_2 and as narrower seams on certain veins; R_{1+2} atrophied or its base preserved; r-m about one-third its length before the fork of Rs; all cells beyond cord elongate; male hypopygium with posterior border of tergite emarginate, the lobes glabrous.

Male.—Length, about 8.5 to 9 millimeters; wing, 10.5 to 11.5; antenna, about 2 to 2.2.

Frontal prolongation of head yellow above, darkened on sides and beneath; nasus conspicuous, with long yellow setæ; palpi with basal two segments light brown, outer two obscure yellow.

Antennæ 12-segmented; proximal three segments light yellow, remainder black; flagellar segments cylindrical, without basal enlargements, longer than the verticils; terminal segment small, oval, about one-fourth the penultimate and much more slender. Head buffy yellow in front, the posterior vertex brownish gray, darker on the anterior vertex which is more or less furrowed longitudinally but without conspicuous tubercles.

Cervical region and propleura dark brown laterally, yellow above. Mesonotal præscutum buffy yellow, the disk with three brown stripes, the central one vaguely divided by a slightly darker brown vitta; scutum with the pale ground reduced, lobes extensively dark brown; scutellum dark brown; mediotergite light brown, with a vague paler central line, pleurotergite testaceous yellow, clearer yellow on the anterior ventral part. Pleura yellow, patterned with brown on the propleura and most of the anepisternum, with a narrower and paler stripe on the forecoxæ and dorsal sternopleurite, the ventral half of the latter light gray. Halteres yellow, knobs dark brown. Legs with forecoxæ weakly darkened, remaining coxæ and the trochanters yellow; remainder of legs very long and slender, dark brown, bases of femora restrictedly yellow; claws very small, simple. Wings (Plate 1, fig. 1) weakly tinged with yellow, prearcular and costal regions strongly brownish yellow; stigma and a cloud over Rs and adjoining veins dark brown; narrower dark brown seams over remainder of cord, along veins Cu and 2nd A, and as a narrow apical band from the wing tip basad; outer two-thirds of cell R_2 conspicuously clouded; veins dark brown, anterior cord still darker, posterior prearcular and costal fields paler. Macrotrichia on longitudinal veins beyond cord, basad of cord lacking on proximal ends of Sc, R and M, virtually lacking on basal section of Cu_1 and the anal veins. Venation: R_{1+2} atrophied or its base indicated by a spur; r-m about one-third its length before fork of Rs; cell M_1 about twice its petiole; cell 1st M_2 small; all cells beyond cord elongate.

Abdomen with basal segments yellow, the second and succeeding tergites brown, the outer ends paler, especially the borders; basal sternites more extensively yellowed, more or less pruinose; outer segments more darkened, hypopygial appendages brownish yellow. Male hypopygium (Plate 3, fig. 39) very simple in structure; posterior border of tergite, *t*, with a broad U-shaped emargination, this much larger than the

obtuse glabrous lateral lobes, remainder of tergite with small weak setæ, narrowly interrupted at the midline, lacking on almost the cephalic half. Outer dististyle, *d*, long and slender, about four times as long as the greatest width; setæ long but relatively sparse; inner style with the beak produced, pale, lower beak blackened, tip truncate. Phallosome, *p*, with low rounded cushionlike apophyses that are provided with short pale setulæ; ædægus broad on basal half, the narrowed outer part blackened.

Habitat.—Sikkim.

Holotype, male, Manu, altitude 4,920 feet, May 10, 1959 (*Schmid*). Paratopotypes, 2 males, one in poor condition.

Macgregoromyia sikkimensis is the most westerly member of the genus so far discovered. Originally described from the Philippines, there now are a dozen known species, all occurring in eastern and southeastern Asia, including four species in Japan, others in eastern and western China, and one in the Malay peninsula. The present fly is generally similar to species such as *M. brevicula* Alexander and *M. perpendicularis* Edwards, differing in coloration, slight details of venation, and in hypopygial structure.

DOLICHOPEZA (MITOPEZA) AMISCA sp. nov. **Plate 1, fig. 2; Plate 3, fig. 40.**

Size medium (wing of male 10 mm); thorax polished orange, virtually glabrous; antennæ of male long, about one-half the wing; wings tinged with brown, the costal border more heavily darkened; sparse macrotrichia in cells at wing tip; cell 1st M_2 small, cell M_1 broadly sessile, cell 2nd A very narrow; abdomen brownish orange, posterior margins of the segments darkened, eighth segment blackened; male hypopygium with dististyles large, pale, outer style unequally bilobed.

Male.—Length, about 8.5 millimeters; wing, 10; antenna, about 5.

Frontal prolongation of head dark brown above, with long black porrect setæ, yellowed beneath; palpi brown, the terminal segment darker at tip. Antennæ of male relatively long; scape, pedicel and base of first flagellar segment yellow, the pedicel with dense black setæ; remainder of organ brownish black; segments elongate, with scattered black verticils on upper aspect, surface with a short dense white pubescence. Head light gray in front, brownish black behind, surface sparsely pruinose.

Pronotum dark brown above, light yellow on sides. Thorax polished orange, scutum and scutellum slightly more brownish orange; mesonotum virtually glabrous, with a few scattered setæ on the scutellum; anterior dorsopleural membrane light yellow. Halteres with stem brownish yellow, knob blackened. Legs with coxæ and trochanters orange; remainder of legs broken. Wings (Plate 1, fig. 2) tinged with brown, the entire costal border to the wing tip strongly infuscated, the stigma a trifle darker; remainder of wing margin very narrowly to insensibly darkened; prearcular field and cell 2nd A slightly infuscated; veins dark brown, conspicuous. Macrotrichia in extreme outer ends of cells R_2 to 2nd M_2; veins with strong strichia basad almost to arculus, lacking on 2nd A and basal fourth of M, virtually lacking on Cu_1. Venation: Sc_2 ending opposite origin of the subtransverse Rs; R_{1+2} preserved as a strong spur that is longer than R_2, provided with trichia; cell 1st M_2 very small; cell M_1 broadly sessile; m-cu nearly one-half its length before the fork of M; cell 2nd A very narrow.

Abdomen brownish orange, polished, posterior borders of segments narrowly infuscated, eighth segment black; hypopygium yellow. Male hypopygium (Plate 3, fig. 40) with the tergite, *t*, glabrous on sides, the margins involuted; lobes on either side of midline with a compact group of about 15 blackened pegs, cephalad of which the disk is densely provided with strong yellow setæ directed chiefly mesad and slightly caudad, with a strong black seta on either side of midline. Dististyles, *d*, of unusual shape, the conformation about as figured, the outer style unequally bilobed; inner style densely setiferous, its apex farther produced into a glabrous blade.

Habitat.—South India (Kerala).

Holotype, male, Tenmalai, altitude 500 to 900 feet, November 26, 1958 (*Schmid*).

Dolichopeza (*Mitopeza*) *amisca* is most similar to the larger *D.* (*M.*) *kanagaraji* Alexander, which differs evidently in the coloration and in the wing venation. *D.* (*M.*) *flavicans* (Edwards) of Ceylon is distinct from the other Indian species of the subgenus in the petiolate cell M_1 of the wings.

DOLICHOPEZA (NESOPEZA) BALLATOR sp. nov. **Plate 1, fig. 3.**

Size medium (wing of female 9 millimeters); general coloration of thorax obscure yellow, abdomen darker; tarsi whitened; wings suffused with brownish yellow, prearcular and costal fields, stigma and outer radial field conspicuously darker brown;

narrow darker brown seams along cord; medial forks shallow; ovipositor with cerci black, relatively stout and flattened, tips slightly decurved.

Female.—Length, about 10 millimeters; wing, 9.

Frontal prolongation of head pale yellowish brown, with black setæ; palpi testaceous brown, terminal segment relatively short, subequal to the combined second and third. Antennæ with scape and pedicel yellow, flagellum brown; flagellar segments long-cylindrical, exceeding the verticils, the latter on segments beyond the first single, placed at near two-thirds the length of the segment; antenna broken beyond the sixth segment. Head light brown, paler on orbits; vestiture consisting of black setæ in a suborbital position, the disk of the vertex glabrous.

Thorax with the interior contents destroyed by insect pests, the color probably paler than in life; entire thorax brownish yellow, without evident pattern; præscutum glabrous, mediotergite with short retrorse setæ. Halteres with stem pale, knob infuscated. Legs with coxæ and trochanters yellow; a single leg (hind) remains, femora and tibiæ brownish yellow, tips of femora narrowly more darkened, of the tibiæ paling into whitish; tarsi white. Wings (Plate 1, fig. 3) suffused with brownish yellow; prearcular and costal fields conspicuously infuscated, paler along the cephalic border of cell R; stigma dark brown; outer ends of cells R_2 and R_3 extensively infuscated; further narrow brown seams along cord; veins light brown. Veins beyond cord with macrotrichia of moderate length, basad of cord lacking on M and 2nd A, a few near outer ends of Cu_1 and 1st A. Venation: Medial forks shallow, cell M_1 subequal to its petiole; cell 2nd A relatively broad.

Abdomen light brown; cerci black, relatively stout and flattened, their tips slightly decurved; hypovalvæ shorter, black at base, the acute tips pale.

Habitat.—Sikkim.

Holotype, female, Bichu, altitude 8,000 to 8,500 feet, July 14, 1959 (*Schmid*).

Dolichopeza (*Nesopeza*) *ballator* is quite distinct from all other described regional members of the subgenus in the pattern of the wings. The most similar species is *D.* (*N.*) *infuscata* Brunetti, which differs in the coloration of the body, legs and wings, and in the venation.

DOLICHOPEZA (NESOPEZA) PRAESUL sp. nov. **Plate 1, fig. 4; Plate 3, fig. 41.**

Size large (wing about 15 millimeters); general coloration of head and thorax dark brown; antennæ short; legs brown, outer tarsal segments white; wings strongly blackened; Rs long, medial forks deep; male hypopygium with the tergal plate blackened, posterior border emarginate; ninth sternite on either side swollen, with very long setæ; eighth sternite deeply emarginate, the lobes with abundant microscopic roughenings.

Male.—Length, about 11 to 12 millimeters; wing, 14 to 15; antenna, about 2.1 to 2.2.

Female.—Length, about 12 to 13 millimeters; wing, 15 to 16.

Rostrum brownish black; palpi elongate, black. Antennæ of male relatively short; scape and pedicel brownish yellow, flagellum black; proximal flagellar segments elongate, progressively shortened outwardly, with conspicuous verticils; outer segments and their verticils shorter, suboval to slightly produced beneath, the setæ of the tumid part very short and spinoid. Head with front obscure yellow, vertex dark brown, the low tubercle paler, its weakly emarginate apex more yellowed.

Pronotum brownish black. Mesonotum dark brown, the præscutum with vague indications of four slightly paler stripes; vestiture of præscutum short and sparse, of the scutellum longer, of mediotergite very long and delicate. Pleura brown, including the dorsopleural membrane. Halteres with stem brownish yellow, knob dark brown. Legs with coxæ brown, trochanters more brownish yellow; femora brown, slightly paler basally; tibiæ and basitarsi brownish black, remainder of tarsi white; claws small, simple. Wings (Plate 1, fig. 4) strongly blackened, especially cell Sc and the stigma; a darkened seam in cell M adjoining vein Cu; veins dark brown, R_1 and its outer veins, together with bullate areas on cord, pale. Macrotrichia present on veins beyond cord, lacking on basal section of Cu_1 and the anals, excepting one or two near outer ends of the latter veins; a few trichia at outer end of M. Venation: Sc_2 ending opposite or beyond the fork of Rs, the latter long, in alignment with the elongate R^{2+3}; medial forks deep, cell M_1 about three times its petiole; cell 2nd A moderately broad.

Abdominal tergites dark reddish brown, their posterior borders darker; sternites obscure brownish yellow, the apical margins slightly darkened; outer segments more uniformly blackened, the outer part of the eighth and ninth sternites

paling to brown. Male hypopygium (Plate 3, fig. 41) with the tergal plate, *t*, blackened, its posterior border broadly emarginate, the lateral parts produced cephalad. Ninth sternite, *s*, globose beneath on either side, provided with abundant very long setæ. Outer dististyle, *d*, elongate, darkened, slightly dilated on outer end, with long setæ; inner style obtuse at apex. Phallosome, *p*, in addition to the ædeagus, includes a large depressed-flattened plate, its apex biemarginate. Eighth sternite, *8s*, conspicuously emarginate medially, the lobes with abundant microscopic roughenings, on the sides with delicate setulæ.

Habitat.—South India (Madras).

Holotype, male, Senbaganur, altitude 5,500 to 6,500 feet, December 7, 1958 (*Schmid*). Allotopotype, female, pinned with type. Paratopotypes, 2 males, 1 female.

Dolichopeza (*Nesopeza*) *præsul* is the largest regional member of the genus so far discovered. It is most similar to species such as *D.* (*N.*) *compressior* Alexander, differing from all in the large size, venation, and especially in the structure of the male hypopygium, including the tergite, 8th and 9th sternites, and the phallosome.

TIPULA (BELLARDINA ARJUNA sp. nov. **Plate 3, fig. 42.**

Size medium (wing of male from 19 to 24 millimeters); general coloration of mesonotum almost uniformly chestnut brown, pleura conspicuously patterned, the dorsopleural membrane light yellow, beneath this with longitudinal stripes of blue gray and dark brown; legs yellow; wings almost uniformly light brown, restrictedly patterned with pale and darker areas; abdomen, including hypopygium, brownish yellow, tergites narrowly bordered by dark brown; male hypopygium with the outer tergal margin produced into two low glabrous lobes.

Male.—Length, about 17 to 21 millimeters; wing, 18 to 24; antenna, about 4.5 to 5.5.

Female.—Length, about 20 to 24 millimeters; wing, 23 to 28.

Frontal prolongation of head long, chestnut brown; nasus long, black; palpi with proximal three segments brownish yellow, terminal segment beyond its base blackened. Antennæ with scape light brown, succeeding segments yellow, slightly and vaguely darkened on the very small basal enlargements of the outer flagellar segments; verticils subequal to or slightly longer than the segments. Head chestnut brown, with a con-

spicuous blackened stripe extending from the summit of the entire vertical tubercle to the pronotum, posterior orbits and sides of the posterior vertex with a light gray shimmer.

Pronotum medially dark brown to brownish black, abruptly light yellow on side. Mesonotal præscutum almost uniformly dark chestnut brown, with faint indications of darker lines that represent the narrow borders of four stripes, lateral præscutal margin darker brown; scutum chestnut brown, vaguely patterned with darker brown; scutellum darker brown, with a faint still darker central vitta; mediotergite light blue gray, pleurotergite with the anapleurotergite brownish yellow, katapleurotergite blackened above, blue gray beneath; scutellum and mediotergite with long delicate erect setæ. Pleura conspicuously patterned, including the broad light yellow dorsopleural region, immediately beneath which is a blackened stripe, extending from the cervical region to the pleurotergite, somewhat paler and interrupted before the latter; a blue gray longitudinal band, narrowly bordered above by chestnut brown, beneath on the ventral sternopleurite by darker brown; meral region more pruinose, metapleura yellowed. Halteres with stem dusky, knob infuscated at base, apex obscure yellow. Legs with the coxæ blue gray; trochanters brownish yellow, darkened beneath; femora yellow, very weakly and narrowly darkened at tips; tibiæ yellow; tarsi light brown, outwardly passing into black; claws of male small, toothed. Wings chiefly and almost uniformly light brown, the anterior margin, with the outer radial cells, more yellowish brown, cell Sc yellow; stigma small, slightly darker than the ground; a major dusky cloud over outer end of cell 1st M_2 and fork of M_{1+2}; two white areas on basal half of wing in cell Cu, the larger outer one extending cephalad into cell M, the basal spot extended posteriorly across cell 1st A; small white marginal spots in centers of cells R_5 to M_4, inclusive, more extensively bordered at the veins by darker brown; in cases with very small pale spots before and beyond the origin of Rs; obliterative band at cord and into cell 1st M_2 variable, in cases conspicuous; veins yellow, somewhat darker in the prearcular field. Macrotrichia of veins well distributed over the wing, including some of the prearcular veins. Venation: Cell R_3 not constricted at midlength; petiole of cell M_1 about one-half m.

Abdomen chiefly brownish yellow, the lateral tergal borders dark brown, with a small light gray spot at posterior end;

hypopygium concolorous. Male hypopygium (Plate 3, fig. 42) with the tergite, *t*, transverse; posterior border slightly convex, with two submedian obtuse lobes that have about the same conformation as the median emargination; lobes glabrous, the surface behind with abundant setæ that are long and conspicuous on the sides, smaller on the disk, becoming exceedingly small but numerous immediately behind the lobes. Dististyles, *d*, about as shown, the outer one larger, its basal part produced outwardly into a point, the broader apex terminating in an obtuse lobe that is provided with abundant long setæ on upper surface and even more numerous shorter bristles beneath; inner style produced into a long arm, the obtuse outer end glabrous, the central part with relatively sparse coarse setæ.

Habitat.—Kumaon, Sikkim.

Holotype, male, Yangtang, Sikkim, altitude 11,200 feet, June 28, 1959 (*Schmid*). Allotype, female, Namnasa, Sikkim, altitude 9,500 feet, July 12, 1959 (*Schmid*). Paratypes, 1 male, 1 female, with the allotype, July 12 to 13, 1959; male, Chachu, Sikkim, altitude 11,500 feet, May 29, 1959; male, Shingba, Sikkim, altitude 10,400 feet, June 30, 1959; male, Yedang, Sikkim, altitude 10,600 feet, June 9, 1959; 2 males, Yoksam, Sikkim, altitude 5,600 feet, September 30, 1959; male, Dhur, Almora, Kumaon, altitude 7,400 feet, September 9, 1958; male, Kulara, Pauri Garhwal, Kumaon, altitude 12,000 feet, August 4, 1958 (all *Schmid*).

The name of this striking crane fly, *arjuna*, is that of the Prince of India in the Bhagavad-gita. In its thoracic coloration it most suggests the otherwise very different *Tipula* (*Bellardina*) *hobsoni* Edwards and *T.* (*B.*) *krishna* sp. nov. These species bear a superficial resemblance to certain tropical American species of the same subgenus and also to some members of the genus *Holorusia* Loew.

TIPULA (BELLARDINA) HYPSISTOS sp. nov. **Plate 3, fig. 43.**

Size medium (wing 16 to 21 millimeters); general coloration of thorax gray, præscutum with four faintly differentiated stripes; antennal pedicel light yellow, flagellum black; femora obscure yellow, tips narrowly black; wings grayish brown, tesselated with yellowish areas forming a zigzag pattern before the cord, cells C and Sc light yellow; basal abdominal segments yellowish brown, outer ones darkened; male hypopygium with the tergite terminating in a decurved broad simple lobe that

is densely provided with blackened spinoid setæ; outer dististyle unequally trilobed.

Male.—Length, about 15 to 17 millimeters; wing, 16 to 21; antenna, about 4 to 4.3.

Female.—Length, about 19 millimeters; wing, 19.

Frontal prolongation of head dark brown, relatively long, without nasus; palpi brown. Antennæ of moderate length; scape brownish yellow, pedicel clear yellow, flagellum black; flagellar segments with small basal enlargements, subequal in length to the longest verticils. Head gray; a central dark brown vitta extending from the summit of the low vertical tubercle backward almost to the occiput.

Pronotum brown, vaguely patterned with paler. Mesonotal præscutum gray, clearer laterally, with four faintly differentiated stripes that are best indicated by narrow blackish borders, the outer margins of the intermediate stripes especially distinct; median dark vitta divided before midlength, behind enclosing a gray line; lateral stripes bordered outwardly with blackish; scutal lobes each with two brown areas, the anterior one small; scutellum plumbeous gray; mediotergite gray, with a narrow central darkened line that is pointed behind. Pleura light gray, on ventral part vaguely patterned with darker; dorsopleural membrane infuscated. Halteres elongate, stem obscure yellow, knob more darkened basally, tip paler. Legs with coxæ and trochanters brownish gray; femora obscure yellow, tips narrowly black, the amount subequal on all legs; tibiæ light brown, tarsi passing into black; claws of male small, toothed. Wings grayish brown, variegated by yellowed areas, forming a tesselated or zigzag pattern in the cells before the cord; outer third of wing with a major brightening beyond stigma and in bases of the outer radial cells, with small pale brown; cells C and Sc light yellow. Veins with macrotrichia throughout their lengths or virtually so. Venation: Petiole of cell M_1 subequal to m.

Basal abdominal segments yellowish brown, the posterior borders of the tergites restrictedly pale; outer segments more uniformly darkened, more extensively so on the sternites. Male hypopygium (Plate 3, fig. 44) with the tergite, *t*, transverse, narrowed outwardly, posterior border truncate, the actual apex decurved and showing beneath, terminating in a simple low broad lobe that is densely provided with spinoid black bristles, the remaining upper surface with abundant longer

setæ. Dististyles, *d*, distinctive, short and compact; outer style trilobed, including a larger outer lobe, very obtuse at apex, surface with long pale setæ; inner lobe a little smaller, obtuse, the vestiture more sparse, chiefly at and near apex subtruncate, surface sparsely setiferous, the bristles more numerous at the outer angles; inner style about as long but slender, broadest on basal half, constricted at midlength, the outer end expanded, very obtuse, almost glabrous, with a few microscopic bristles on the disk.

Habitat.—Sikkim.

Holotype, male, Gurudongmar Cho, altitude 17,000 feet, June 23, 1959 (*Schmid*). Allotopotype, female, pinned with the type. Paratopotypes, 4 males, with the types; paratype, male, Donkung, Sikkim, altitude 15,750 feet, June 22, 1959 (*Schmid*).

The types were collected at light, near a mountain torrent. This is the highest altitude at which crane flies have been taken in the Himalaya, but it may be indicated that in the Bolivian Andes a species of *Limonia* has been taken at even higher altitudes.

Tipula (*Bellardina*) *hypsistos* is most similar to species such as *T.* (*B.*) *trilobata* Edwards, of Yunnan, differing especially in the coloration of the body, toothed claws, and structure of the hypopygium, particularly of the tergite.

TIPULA (BALLARDINA) KRISHNA sp. nov. **Plate 3, fig. 43.**

Allied to *hobsoni;* size very large (wing of male to 28 millimeters); head and pronotum darkened medially above; mesonotum chestnut brown, pleura brown, conspicuously pattered with darker brown and yellow; legs chestnut brown, outer tarsal segments black; wings light brown, patterned with two major cream-colored areas before the cord, with further light and darker markings; abdomen very stout, orange; hypopygium very large, darker brown; posterior border of tergite produced into two fingerlike lobes; both dististyles heavily sclerotized and blackened, produced into spines.

Male.—Length, about 24 to 25 millimeters; wing, 26.5 to 28; antenna, about 6.

Frontal prolongation of head long, dark chestnut brown above, dark brown on sides and beneath; nasus elongate; proximal two segments of palpi brown, the third more reddened, terminal segment brownish black. Antennæ with scape light brown, gray pruinose; remainder of organ orange, the bases

of the flagellar segments darkened at point of insertion of the long verticils. Head reddish brown, sides of posterior vertex gray pruinose; a very broad dark brown longitudinal stripe extends from the summit of the entire vertical tubercle backward, on the cervical region passing into black.

Pronotum above dark chestnut brown, abruptly light yellow on sides. Mesonotum almost uniformly chestnut brown, contrasting abruptly with a light yellow area that extends from the head to the wing root over the dorsopleural region. Pleura light brown above, its superior border narrowly more darkened; dorsal sternopleurite with a large silvery area that crosses the pteropleurite onto the katapleurotergite, ventral sternopleurite yellow; meron and metapleura with silvery sheen. Halteres yellow. Legs with the fore- and middle coxæ chestnut, posterior pair more yellowed, all with long pale setæ; trochanters chestnut brown; remainder of legs chestnut brown, the tips of the basitarsi and remainder of tarsi black; claws with an obtuse tooth. Wings strongly suffused with light brown, cell Sc more yellowish brown; two major cream-colored areas before cord, one crossing cells Cu and 1st A before midlength, the second at the outer two-thirds of cell M; a series of small pale marginal spots in centers of cells R_5 to 1st A, the alternating tips of the veins dark; a narrow and inconspicuous yellow subbasal band in cells R_2 to R_5, inclusive; somewhat darker areas at midlength of cell Cu, cord and outer end of cell 1st M_2; small obliterative areas before stigma, in outer end of cell R and in base of cell 1st M_2; veins brownish yellow, Sc, R and M more orange, C and prearcular veins darker. Venation: Cell R_3 slightly constricted before midlength; petiole of cell M_1 shorter than m.

Abdomen very stout, bright orange, the massive hypopygium more chestnut brown. Male hypopygium (Plate 3, fig. 43) described and figured from the dried type so the internal structures are incomplete and possibly not entirely accurate. Ninth tergite, *t*, large and tumid, its posterior border produced into two long fingerlike compressed-flattened lobes that are directed caudad and ventrad, tips obtuse, surface with setæ. Basistyle and sternite chiefly fused, the suture indicated beneath, outer lobe of the former densely silvery pruinose. Dististyles, *d*, heavily blackened and sclerotized; outer style appearing as two flattened outer blades, their tips narrowly obtuse, lower plate with long pale setæ, on margin at near midlength with an

acute tooth; it appears that the style is farther produced inwardly into a yellow plate that is again armed with a spine; inner style a long slender blackened spine from a small dilated base, curved outwardly, tip pale, apex acute. Lobes of ninth sternite oval, polished, almost contiguous at the midline.

Habitat.—Sikkim.

Holotype, male, Namnasa, altitude 9,500 feet, July 12, 1959 (*Schmid*). Paratype, 1 male, Karponang, altitude 8,100 feet, August 22, 1959 (*Schmid*).

The specific name, *krishna,* is that of the Hindu deity who communicated with Arjuna, the Prince of India, in the Bhagavad-gita. This magnificent fly is related to *Tipula* (*Bellardina*) *arjuna* sp. nov. and *T.* (*B*) *hobsoni* Edwards, differing in details of coloration of the body but especially in the very distinctive structure of the hypopygium. In its general appearance, especially the coloration of the body and wings, it strongly suggests an unusually large specimen of *arjuna.*

LIMONIINÆ

LIMONIINI

PROTOHELIUS NILGIRICUS Alexander. **Plate 1, fig. 5; Plate 3, fig. 45.**

Protohelius nilgiricus ALEXANDER, Ent. News 71 (1960) in press.

Type, male, Cherangode, Nilgiri Hills, Madras, altitude 3,500 feet, November, 1950 (*Susai Nathan*).

Male.—Length, about 6 millimeters; wing, 6.5; antenna, about 1.8.

General coloration of thorax brownish yellow, with large and conspicuous blackened areas on sides of præscutum, scutal lobes and pleurotergite; legs yellow; wings (Plate 1, fig. 5) subhyaline, stigma short-oval, dark brown.

Male hypopygium (Plate 3, fig. 45) with the outer dististyle, *d,* blackened except at base, the termination elongate, more than three times the lateral lobe; inner style a little longer, pale, the terminal portion about twice its lower lobe, the latter with conspicuous setæ.

This is the first record of occurrence of the genus in India.

LECHRIINI

LECHRIA COORGENSIS Alexander. **Plate 1, fig. 6.**

Lechria coorgensis ALEXANDER, Ent. News 71 (1960) in press.

Type, male, Ammatti, South Coorg, India, altitude 3,100 feet, May, 1951 (*Susai Nathan*).

Male.—Length, about 5 millimeters; wing, 5.7; antena, about 1.1.

Female.—Length, about 6.5 millimeters; wing, 5.3.

Size small; general coloration of pronotum and mesonotum orange, posterior sclerites of latter darker, pleura dull orange; wings (Plate 1, fig. 6) weakly tinged with brown, prearcular and costal fields more yellowed; tip of R_{1+2} atrophied, R_2 before the radial fork, cell 1st M_2 long, m-cu at or before the fork of M; abdomen of male black, hypopygium dull orange.

PEDICIINI

NASITERNELLA GRALLATOR sp. nov. **Plate 3, fig. 46.**

Subapterous in both sexes; size medium (length of male about 8 millimeters, wing, 1.5); general coloration brown; legs long and slender in both sexes.

Male.—Length, about 7.5 to 8.5 millimeters; wing, 1.5 to 1.6; antenna, about 1.2 to 1.3. Foreleg, femur 7; tibia, 7; tarsus, 10. Hind leg, femur 6.7; tibia, 8; tarsus 10.5.

Female.—Length, about 9 to 9.5 millimeters; wing, 1.4 to 1.5.

Rostrum and palpi short, dark brown. Antennæ (Plate 3, fig. 46) short, dark brown, 13 to 15-segmented; flagellar segments beyond the first very short and crowded, transverse; certain segments, both at base and near tip of flagellum more or less fused; verticils very small. Head brownish gray, the center of the anterior vertex more darkened.

Pronotum yellowish brown to light brown. Mesonotum brownish gray, præscutum with a slightly darker central stripe, the anterior and lateral borders more blackened; vestiture short. Pleura grayish brown, the dorsal sternopleurite blackened. Halteres elongate, stem yellowed, knob darkened, the tip paler. Legs long and slender in both sexes, as shown by the measurements; coxæ and trochanters brownish gray; remainder of legs black, the extreme bases of fore-femora yellowed. Subapterous in both sexes, wings, reduced to straplike structures that are subequal to or slightly longer than the halteres, light brown basally, passing into brownish black; venation entirely distorted.

Abdomen dark brown, the basal segments somewhat lighter in color, in the female the abdomen paler brown, the posterior borders of the segments narrowly pale. Ovipositor with the cerci appearing as broad flattened blades, the tips obtuse. Male hypopygium (Plate 3, fig. 46) with the basistyle, *b*, nar-

rowed outwardly, apex obtuse, with a concentration of black spinoid setæ, with a row of similar bristles down the face of style; outer face of style at midlength with many long yellow bristles; mesal face before apex with a small curved lobe that is densely provided with long yellow setæ, forming a terminal brush. Interbase a weak slender rod, gradually narrowed to the obtuse tip. Dististyle, *d*, single, a large powerful structure, stout at base, at near midlength bent at more than a right angle into a straight blade, its tip acute. Ædeagus, *a*, slender, the apex a small head.

Habitat.—Sikkina.

Holotype, male, Gey, altitude 12,000 feet, in *Rhododendron* association, May 20, 1959 (*Schmid*). Allotopotype, female, pinned with type. Paratopotypes, 8 of both sexes, May 18 to 20, 1959 (*Schmid*).

This unusually interesting crane fly is told from all regional Pediciine crane flies by the nearly apterous condition in both sexes. I am referring it to the genus *Nasiternella* rather than to *Pedicia* (*Tricyphona*) because of the structure of the male hypopygium. The specific name refers to the very long stilt-like legs.

NASITERNELLA TJEDERI sp. nov. **Plate 1, fig. 7; Plate 5, fig. 47.**

Size small (wing less than 10 millimeters); general coloration of thorax yellow, præscutum with a faint central darkening; femora blackened, with a broad obscure yellow subterminal ring; wings yellow, with four more or less complete transverse brown crossbands; vein Sc_2 very far retracted, the basal section of R shorter than the second; abdomen dark brown, patterned with yellow; male hypopygium with the spine of the dististyle relatively short, outer setiferous brush with abundant long setæ.

Male.—Length, about 8 millimeters; wing, 9.5 to 9.7; antenna, about 1.2.

Rostrum very short, light yellow; palpi reduced to two segments, the first yellow, the second brown. Antennæ 14-segmented; scape and pedicel light yellow, flagellum brownish black; first flagellar segment about one-third to one-half longer than the second; intermediate segments suboval, with short verticils; terminal segment a little longer than the penultimate. Head brownish gray, posteriorly with long setæ.

Pronotum light yellow. Mesonotum pale yellow, with two very pale-brown central stripes that are barely indicated on their inner edge by slightly darker lines; præscutal vestiture reduced to a few small setæ on the interspaces; scutellum with longer pale setæ. Pleura pale yellow; ventral sternopleurite slightly darker. Halteres yellow. Legs with the coxæ and trochanters yellow; femora brownish black with a broad but diffuse yellow ring before the blackened tips; tibiæ yellowish brown, tips narrowly blackened; tarsi yellowish brown, the outer segments slightly darker. Wings (Plate 1, fig. 7) with the ground yellow, with four more or less complete brown crossbands, placed beyond arculus, at level of origin of Rs, cord and across the outer forks, the first two narrowly interrupted in cell 1st A and interconnected along vein Cu, the outer band more extensively broken in cells R_5 and M_3; in the costal field the areas are heavier, subequal to or exceeding the interspaces which are clearer yellow; additional small marks at h, tip of vein 2nd A, and end of R_3; still less evident marginal seams at ends of veins M_3 and 1st A; veins light yellow in the ground, darkened in the patterned areas. In both available specimens there is a dusky line delimiting the stigma behind, extending from the outer end of cell C, almost reaching vein R_{s+z}, beyond vein R_2 paralleling vein R_{1+2} to the margin. Venation: Sc_1 ending some distance beyond end of Rs, Sc_2 very retracted, the first section of vein R shorter than the second; cell R_4 subequal to its petiole; r-m variable in position, from before the fork of Rs (as shown) to shortly beyond the fork; cell 1st M_2 long, m connecting veins M_2 and M_3; m-cu at or shortly beyond fork of M; supernumerary crossvein in cell M just before the level of origin of Rs, the latter strongly arcuated to square and short-spurred near origin.

Abdomen dark brown, the posterior borders of the tergites yellowed, the amount decreasing on the outer segments; sternites brown, their bases extensively obscure yellow, the tips more narrowly so; hypopygium yellowish brown. Male hypopygium (Plate 3, fig. 47) with the basistyle, *b*, narrowed at apex, with relatively sparse blackened spinoid setæ and interpolated very long setæ; accessory subterminal lobe with similar spinoid setæ; interbase an oval blade with sclerotized borders. Dististyle, *d*, a powerful arm, bent and narrowed at a right angle into an acute spine, much shorter than in other members of the genus; at its base on outer margin with a second arm that is densely setiferous to form a brush.

Habitat.—Sikkim.

Holotype, male, Chateng, altitude 8,000 feet, July 28, 1959 (*Schmid*). Paratopotype, male.

I take great pleasure in dedicating this conspicuous fly to Dr. Bo Tjeder, of Falun, Sweden, critical student of the Tipulidæ and other groups of Diptera. It is quite distinct from the northern and subarctic species that center around *Nasiternella hyperborea* (Osten Sacken) and *N. variinervis* (Zetterstedt), the latter being the genotype. It is even more removed from the only other known fully winged regional species *N. ignara* (Alexander), of northern Burma.

PEDICIA (TRICYPHONA) SAKKYA sp. nov. **Plate 1, fig. 8; Plate 3, fig. 48**

Size medium (wing of male 11 millimeters); general coloration of thorax brownish yellow, præscutum with four dark brown stripes; legs black; wings fulvous brown, the base more yelowed; vein R_{4+5} subequal to r-m, cell M_1 present, cell 1st M_2 small; male hypopygium with the tergite transverse, posterior border broadly emarginate; interbase appearing as a small flattened yellow blade.

Male.—Length, about 9.5 millimeters; wing, 11; antenna, about 1.4.

Rostrum and palpi brownish black. Antennæ 16-segmented, brownish black; flagellar segments subcylindrical, the more proximal ones more crowded and closely applied to one another; segments longer than the appressed vestiture. Head dark gray.

Pronotum grayish brown. Mesonotal præscutum brown, yellow pollinose, with four distinct dark-brown stripes, the median interspace dusky; posterior sclerites of notum brown, yellow pollinose, each scutal lobe with two dark-brown areas, the anterior one very scall; posterior part of mediotergite more darkened. Pleura brownish gray. Halteres obscure yellow, knobs large. Legs with forecoxæ brown, remaining covæ and all trochanters more yellowed; remainder of legs black. Wings (Plate 1, fig. 8) fulvous brown, the base more yellowed; veins pale brown, those in the costal region yellowed. Abundant long macrotrichia on veins excepting near wing base, including numerous trichia on r-m in the holotype but not in the paratype. Venation: Sc_2 not evident in the available material; cell R_3 sessile, vein R_{4+5} subequal to r-m; cel M_1 long, three to four times its petiole; cell 1st M_2 small, more so in the type; m-cu at near one-third the length of M_{3+4}.

Abdomen with proximal five segments light brown, the remainder dark brown. Male hypopygium (Plate 3, fig. 48) with the tergite, *t*, transverse, very narrow at midwidth, posterior border broadly emarginate to form large obtuse lobes, surface with abundant setæ; tergal arms ventral, appearing as stout sclerotized rods, at apex bent laterad into an acute point. Basistyle, *b*, with the interbase a small flattened yellow blade, apex obtuse; basistyle with two apical lobes, subequal in size, the outer with sparse spinoid setæ near apex and with very long yellow setæ; inner lobe more narrowed basally to appear clavate, its outer half with very numerous black spinoid setæ, longer and more slender than those of the outer lobe. Dististyle, *d*, a simple flattened obscure yellow blade, gently curved to the obtuse tip, lower margin of outer half with numerous small setæ. Phallosome with gonapophyses appearing as small oval lobes, directed inwardly.

Habitat.—Sikkim.

Holotype, male, Tung, altitude 4,500 feet, August 2, 1959 (*Schmid*). Paratopotype, male.

The specific name, *sakkya*, is that of the Tibetan deity responsible for the common prayer, "Om mani padmi om." *Pedicia* (*Tricyphona*) *sakkya* is very distinct from all others so far discovered in the Himalayan region. It is most similar to certain Nearctic species that are allied to *P.* (*T.*) *diaphana* (Doane), differing in all details of structure of the hypopygium.

DICIANOTA (RHAPHIDOLABINA) MAGRA sp. nov. **Plate 1, fig. 9; Plate 4, fig. 49.**

Size small (wing of male about 6 millimeters); general coloration yellow, præscutum with four brown stripes; thoracic pleura with a large dark-brown area on mesepisternum; knobs of halteres darkened; legs yellow; wings weakly yellowed, restrictedly patterned with brown; R_{4+5} elongate, with r-m before midlength; male hypopygium with a single appendage at apex of basistyle interpreted as being the dististyle; gonapophysis elongate, before apex on outer margin with a compact group of four strong spines.

Male.—Length, about 5 to 5.5 millimeters; wing, 5.8 to 6; antenna, about 0.9.

Female.—Length, about 6.5 to 7 millimeters: wing 6.5 to 8.

Rostrum and palpi light yellow. Antennæ yellow, 15-segmented; proximal two or three flagellar segments enlarged and

more or less fused; succeeding segments elongate, with very long verticils that exceed the segments. Head yellow.

Pronotum yellow. Mesonotum yellow, the præscutum with four brown stripes; each scutal lobe with a major darkened area; mediotergite darkened posteriorly. Pleura yellow, the anepisternum and sternopleurite dark-brown, forming a conspicuous transverse stripe. Halteres with stem yellow, knob dark brown. Legs with forecoxæ yellow, middle and hind pairs darkened; trochanters yellow, middle and hind pairs darkened, especially beneath; remainder of legs light yellow, the terminal tarsal segments weakly infuscated. Wings (Plate 1, fig. 9) weakly yellowed, slightly patterned with darker, including small brown spots at arculus, Sc_2, origin of Rs, cord, outer end of cell 1st M_2, R_2, and forks of R_{4+5} and M_{1+2}; stigma yellowed, narrowly ringed with pale brown; outer radial cells washed with pale brown, cell R_2 more whitened; very small to scarcely evident brown marginal spots on veins R_3 to 2nd A, inclusive; veins yellow, darker in the patterned areas. Macrotrichia on veins beyond cord, basad of this with sparse trichia on Rs and on outer half of 2nd A. Wings of male more dilated, widest opposite termination of vein 2nd A. Venation: Rs long, angulated at origin; R_{1+2} very short, vein R_3 arcuated, R_{4+5} long, with r-m before midlength; cell M_1 subequal to its petiole; cell 1st M_2 strongly widened outwardly; m-cu close to the fork of M.

Abdominal tergites brown, sternites more bicolored, darkened basally, more broadly obscure yellow on outer part. In the female, abdomen more yellowed, basal rings darkened. Male hypopygium (Plate 4, fig. 49) with the tergite, *t*, transverse, posterior border produced into a broad obtuse central lobe and lateral flattened blades. Basistyle, *b*, with a single terminal structure that is interpreted as being the dististyle, *d*, smaller than the basistyle, produced into a broad beak, with spinoid setæ, chiefly concentrated into two groups, one at summit of style, the second at outer end of beak; setæ of body of style very long, especially on mesal aspect. Gonapophyses, *g*, appearing as paired straight rods, the tip of each produced into a hyaline point, at base of latter with an erect compact group of strong spines.

Habitat.—Sikkim.

Holotype, male, Chumtang, altitude 5,120 feet, July 18, 1959 (*Schmid*). Allotype, female, Tung, altitude 4,500 feet, August

2, 1959 (*Schmid*). Paratypes, a fragmentary female on slide with the allotype; 1 male, Nanga, altitude 5,000 feet, August 4, 1959; 1 female, Teng, altitude 4,600 feet, August 1, 1959 (all *Schmid*).

Dicranota (*Rhaphidolabina*) *magra* is named for an aboriginal Sikkimese tribe discussed by Hooker in his "Himalayan Journals." It is readily distinguished from other regional members of the subgenus, including *D.* (*R.*) *reticularis* Alexander and *D.* (*R.*) *trichoneura* Alexander, by the coloration of the body and wings, venation, especially of the radial field, and the structure of the male hypopygium.

DICRANOTA (RHAPHIDOLABINA) MEGOMMA sp. nov.
Plate 1, fig. 10; Plate 4, fig. 50.

General coloration of body black, including the abdomen; eyes of male very large; wings broad, weakly tinged with brown, restrictedly patterned with still darker brown; cell M_1 lacking, cell 1st M_2 long, closed.

Male.—Length, about 5 millimeters; wing, 6; antenna, about 1.2.

Rostrum reduced, brown; palpi short, apparently 3-segmented. Antenna dark brown, tip broken, with 13 segments preserved; basal three or four flagellar segments crowded, short suboval, the outer ones passing into suboval; verticils short. Head large, comprised chiefly of the compound eyes which are broadly contiguous beneath, narrowly separated above by the vertex.

Thorax uniformly black, surface subnitidous by a very sparse pruinosity; præscutum with a poorly defined broad central more blackened stripe; dorsopleural membrane dark brown. Halteres with stem brown, apex of knob brownish black. Legs with coxæ dark brown, paler beneath; trochanters brownish yellow; remainder of legs brownish black, femoral bases slightly more yellowed; claws long, unusually straight. Wings (Plate 1, fig. 10) broad, weakly tinged with brown, prearcular and costal fields slightly more yellowed; stigmal region vaguely brownish yellow; faint darker clouds at origin of Rs, cord, R_2, and outer end of cell 1st M_2; veins light brown, darker in the clouded parts, Cu_2, and a faint line behind vein 2nd A more yellowed. Macrotrichia of veins small and sparse, beyond cord with a few on R_3, tip of R_4, outer two-thirds of distal section of R_5, distal sections of M_{1+2} and M_3, and a very few on M_4; none

on veins before cord, Sc, or about the proximal half of R. Venation: Sc_1 ending beyond fork of R_{2+3+4}, Sc_2 far before origin of Rs, the latter long; R_{2+3+4} short, suberect, less than r-m, subequal to R_2; r-m on R_5; cell M_1 lacking, cell 1st M_2 closed, long, gradually widened outwardly, m-cu more than one-half its length beyond the fork of M.

Abdomen brownish black, hypopygium black. Male hypopygium (Plate 4, fig. 50) with the tergite, *t*, extensive, central region of posterior border very slightly convex; lateral arms very long, broad and darker at base, before tip arcuated and thence narrowed into a spine. Basistyle, *b*, with a stout lateral densely setiferous cushion, apex narrowed into an unusually slender lobe that is provided with a few spinoid setæ, its tip farther extended into a still more slender lobule; body a basistyle with unusually long setæ; interbase a long yellow spine from an expanded base, gradually narrowed to the acute tip. Phallosome, *p*, including slender apophyses.

Habitat.—Sikkim.

Holotype, male, Gey, altitude 11,650 feet, in Rhododendron association, May 18, 1959 (*Schmid*).

Dicranota (*Rhaphidolabina*) *megomma*, while very different in its general appearance from *D.* (*R.*) *niphas* sp. nov., is closely related, as shown by the structure of the head and hypopygium, and the venation. The two flies are very distinct in the coloration of the body and wings.

DICRANOTA (RHAPHIDOLABINA) NIPHAS sp. nov. Plate 1, fig. 11; Plate 4, fig. 51.

Size small (wing about 4.5 millimeters); head and thorax black, head and eyes very large; abdomen whitened, base of hypopygium black, styli yellow; halteres and legs white; wings milky white, veins pale, virtually glabrous; cell M_1 lacking, cell 1st M_2 elongate; male hypopygium with the tergal arms and interbase subequal in size, slender; dististyle single, with a slender outer lobe that is provided with small spinules.

Male.—Length, about 4 millimeters; wing, about 4.5.

Rostrum and mouth-parts brownish black. Antennæ darkened, short. Head dull black, very large, holoptic, eyes very large.

Thorax black, dorsum subnitidous, præscutum with sparse erect pale setæ; pleura more opaque. Halteres white. Legs with fore-coxæ blackened, remaining coxæ and trochanters testaceous to white; remainder of legs white, the outer tarsal

segments infuscated. Wings (Plate 1, fig. 11) milky white, including the veins. Veins nearly glabrous; vein R_5 with about two macrotrichia near outer end; costal fringe long but very sparse. Venation: R_{1+2} subequal to R_2; cell 1st M_2 closed, subequal to or longer than distal section of vein M_{1+2}; cell M_1 lacking; m-cu beyond fork of M, in cases to two-thirds its length.

Abdomen whitened, hypopygium black, with whitened styli. Male hypopygium (Plate 4, fig. 51) with the tergite, *t*, extensive, posterior border broadly convex medially, with sparse long setæ; lateral arms long, twisted before the acute terminal spine. Basistyle, *b*, with the interbase subequal in length to the tergal arm, broad-based, narrowed into a long slender spine; outer lobe of basistyle oval, with dense setæ, squamules and pale spinules. Dististyle, *d*, single, including a slender posterior lobe with small spinules and a large flattened blade. Phallosome with the gonapophyses small, darkened, tips obtuse.

Habitat.—Sikkim.

Holotype, male, Chamiteng, altitude 9,900 feet, August 24, 1959 (*Schmid*). Paratopotypes, 13 males, mostly damaged by insect pests. The types were found while flying singly in sunlight near a mountain torrent.

The specific name, *niphas*, a snow-flake, is in reference to the milky white wings. By my key to the subgenera of *Dicranota* [Arkiv f. Zool. (2) 42 A (1949) 17–18], the fly runs to *Rhaphidolabina* Alexander but disagrees with all species, with the exception of *Dicranota* (*Rhaphidolabina*) *megomma* sp. nov., in the lack of cell M_1 of the wings. In its general appearance, especially in the large eyes of the male, it suggests species of the subgenus *Polyangæus* Doane in western North America.

DICRANOTA (AMALOPINA) ELEGANTULA (Brunetti).

Plate 1, fig. 12; Plate 4, fig. 52.

Amalopina elegantula BRUNETTI, Fauna Brit. India, Diptera Nematocera (1912) 517.

The fly was described from an imperfect male taken in the Darjeeling district, West Bengal, May 26, 1910 by Brunetti.

Sikkim: Lingdok, altitude 4,600 feet, May 7, 1959 (*Schmid*).

Manu, altitude 4,920 feet, May 10, 1959 (*Schmid*).

The species has remained unknown since its description. Further notes and figures of essential structures are provided.

Antennæ with scape and pedicel darkened, flagellum yellowish; proximal flagellar segments very crowded and fused,

outer ones elongate, subequal to their verticils. Legs uniformly whitened excepting the entirely brownish-black fore- and middle femora. Wings (Plate 1, fig. 12) broad, widest opposite termination of vein 2nd A, subhyaline, with a restricted brown pattern, appearing as narrow seams at origin of Rs, cord, R_2, the supernumerary crossvein in cell R_4, and outer medial forks; tips of all longitudinal veins with paler brown spots, most extensive on the anal veins. Venation: R_{2+3+4} longer than R_2; r-m connecting vein R_5 with M_{1+2}; cell M_2 open by atrophy of m. The supernumerary crossvein in cell R_4 is normally present, lacking in abnormal specimens. Male hypopygium (Plate 4, fig. 52) much as in other members of the genus. Ninth tergite, *t*, with posterior border low convex medially, with few very long setæ; lateral tergal arms powerful, broad-based, narrowed before the apex which is extended into a slender spine. Basistyle, *b*, with apex trilobed, all lobes with microscopic blackened spicules, the lateral and central ones slender, the mesal lobe extensive; interbase broad at proximal end, its outer half a straight blade, the tip acute. Dististyle, *d*, a simple flattened blade, the tip obtuse. Phallosome with the gonapophyses divaricate, each terminating in a short finger-like lobe, the tip obtuse.

Brunetti describes the venation as having the anterior crossvein (r-m) "uniting the second and third longitudinal veins," which is an impossibility in the order since this crossvein must connect posteriorly with vein M, the fourth longitudinal vein. It is presumed that Brunetti meant that the crossvein connected the third and fourth veins (R_5 with M_{1+2}) and not the second and fourth, which it does in rare cases. In the available material, r-m connects veins R_5 and M_{1+2}.

The present material shows that the nearest ally is the Japanese *Dicranota* (*Amalopina*) *gibbera* (Alexander), hitherto referred tentatively to the subgenus *Rhaphidolabina*. The two species have the same peculiar leg coloration, differing evidently in the hypopygial structure.

HEXATOMINI

LIMNOPHILA (ELÆOPHILA) DELICOLA sp. nov. **Plate 1, fig. 13.**

Size large (wing of female 9.5 millimeters); general coloration of mesonotum buffy, patterned with brown; pleura dark brown, with yellowish gray areas; scape and pedicel black, basal flagellar segments light yellow; femora yellow, each with

a broad black subterminal ring; wings bright yellow, with a conspicuous dark-brown pattern, consisting in part of cross-bands, without dots or spots in the cells.

Female.—Length, about 10 millimeters; wing, 9.5.

Rostrum and palpi black. Antennæ with scape and pedicel black, flagellum light yellow, the outer four or five segments slightly infuscated; basal flagellar segments oval, the outer ones elongate, with long verticils. Head gray, center of the posterior vertex and the occiput broadly brownish black.

Pronotum dark brown. Mesonotal præscutum light brown or buffy, with an intricate dark brown pattern, including the lateral borders, sublateral stripes and narrow intermediate lines on anterior half, interconnected or virtually so; posterior interspace with three small brown spots; a more intensely blackened median vitta on anterior third; pseudo-sutural foveæ and a connected darkening brown; scutum buffy, the lobes patterned with brown; scutellum testaceous yellow, with a darkened spot on either side at base; postnotum dark brown, mediotergite more pruinose. Pleura dark brown, vaguely patterned with areas of yellowish gray pruinosity. Halteres yellow, apical half of knob brownish black. Legs with coxæ dark brown, trochanters slightly paler; femora light yellow, with a black subterminal ring, the narrower apex more reddened; tibiæ yellow, tips narrowly brownish black; tarsi with proximal three segments yellow, tips narrowly darkened, remainder of tarsi brownish black. Wings (Plate 1, fig. 13) bright yellow, more saturated yellow in the prearcular and costal interspaces and along the veins; a conspicuous dark-brown pattern, in part cross-banded as follows: A U-shaped area near wing base, extending to vein 1st A; a narrow parallel-sided band entirely crossing the wing at the level of the supernumerary crossvein; a Y-shaped band at cord, one arm reaching costa at tip of Sc, the other at R_{1+2}; beyond cord an interrupted band extends from outer end of cell R_3 obliquely backward to vein M_3, the apices of the cells broadly yellow; additional brown marks at tip of vein R_3, outer end of cell 1st M_2, fork of M_{1+2}; tips of Cu_1 and 2nd A with very small marginal spots, still smaller on medial veins; no spots or dots in the cell interspaces; veins brown, clear yellow in the ground areas. Wings broadest opposite termination of vein 2nd A. Venation: Cell M_1 about three times its petiole; m-cu shortly beyond fork of M.

Abdominal tergites dark brown, still darker laterally; sternites light yellow, lateral and posterior borders of segments dark brown. Ovipositor with cerci long and slender, basal shield obscure yellow.

Habitat.—Sikkim.

Holotype, female, Karponang, altitude 9,900 feet, August 23, 1959 (*Schmid*).

Limnophila (*Elæophila*) *delicola* is the most distinct member of the subgenus so far discovered in the Himalayan region, being readily told by the large size and striking pattern of the wing. All other regional species have abundant dark spots and lots in the ground interspaces of the wing.

EUPILARIA UMA sp. nov. **Plate 1, fig. 14.**

Size large (wing of female 8.5 millimeters); general coloration dull black, the anepisternum chiefly velvety black; legs with all coxæ uniformly dark brown; wings strongly infuscated, stigma still darker brown, most cells basad of cord with paler centers; Rs long, R_{2+3+4} only about one-third the basal section of R_5; m-cu a short distance beyond fork of M; abdomen uniformly dull black, genital segment obscure orange.

Female.—Length, about 8.5 millimeters; wing, 8.5; antenna, about 1.3.

Rostrum dull brownish black; palpi black. Antennæ with scape and pedicel black, flagellum brownish black; basal flagellar segments short-oval, crowded, outer segments more elongate, with longer verticils. Head dull black.

Pronotum and mesonotum almost uniformly dull black, very sparsely pruinose to appear dark plumbeous. Pleura somewhat paler, the anepisternum velvety black; dorsopleural membrane light brown. Halteres black. Legs with all coxæ uniformly dark brown, trochanters still darker; femora dark brown, bases slightly paler; tibiæ and basitarsi more yellowish brown, tips very narrowly darker; remainder of tarsi brown, passing into black. Wings (Plate 1, fig. 14) strongly infuscated, the stigma still darker brown; most cells before cord with paler centers; veins medium brown. Macrotrichia on most veins beyond cord, including R_3, R_4, distal section of R_5 and outer branches of M; basad of cord lacking on Sc, R_{2+3+4}, M and the anals; Rs with a very few trichia over most of the length; Cu_1 with few trichia on outer end of basal section, with more on the outer section. Venation: Rs longer than in *varaha;* R_{2+3+4} only about one-

third the long nearly straight basal section of R_5; m-cu only a short distance beyond the fork of M.

Abdomen uniformly dull black, genital segment obscure orange. Ovipositor with cerci slender, brownish horn color.

Habitat.—Sikkim.

Holotype, female, Manu, altitude 4,920 feet, May 10, 1959 (*Schmid*).

Eupilaria uma is most similar to *E. varaha* Alexander, of Khasia, differing in the larger size and in the details of coloration and venation.

HEXATOMA (ERIOCERA) GLOMEROSA Alexander. **Plate 1, fig. 15.**

Hexatoma (*Eriocera*) *glomerosa* ALEXANDER, Ent. News 71 (1960) in press.

Type, female, Kollar, Nilgiri Hills, Madras, South India, altitude 1,250 feet, November, 1958 (*Susai Nathan*).

Female.—Length, about 16 millimeters; wing, 15; antenna, about 2.8.

Size medium (wing of female 15 millimeters); antennæ of female 11-segmented; general coloration of thorax light gray, præscutum with four conspicuous dark-brown stripes; dorsopleural membrane of thorax with a conspicuous blackened area; femora and tibiæ obscure yellow, tips very narrowly blackened; wings (Plate 1, fig. 15) tinged with brown, cell C and the small stigma darker; veins of outer radial field stout; R_{2+3} short, about one-half R_{1+2}; abdomen light brown, extreme posterior borders of tergites blackened; ovipositor with long very slender cerci.

ERIOPTERINI

CRYPTERIA (CRYPTERIA) BASISTYLATA Alexander. **Plate 1, fig. 16; Plate 4, fig. 53.**

Crypteria basistylata ALEXANDER, Journ. N. Y. Ent. Soc. (in press, 1960).

Type, male, Tapoban, Pauri Garhwal, India, altitude 7,300 feet, August 2, 1958 (*Schmid*).

Male.—Length, about 3 to 3.5 millimeters; wing, 5 to 5.5.

Size small (wing, 5.5 millimeters or less); thorax uniformly light yellow, abdomen brownish black, basal sternites obscure yellow; halteres and legs white or pale yellow; wings (Plate 1, fig. 16) milky white, veins basad of cord very pale; male hypopygium (Plate 4, fig. 53) with the basistyle, *b*, very long, arcuated or bent at near midlength, dististyles, *d*, terminal,

very small, the outer with appressed teeth on margin before the long terminal spine.

CRYPTERIA (CRYPTERIA) HAPLOA Alexander. **Plate 1, fig. 17; Plate 4, fig. 54.**

Crypteria haploa ALEXANDER, Journ. N. Y. Ent. Soc. (in press, 1960).

Type, male, Kulara, Pauri Garhwal, India, altitude 12,000 feet, August 3, 1958 (*Schmid*).

Male.—Length, about 4.5 to 5 millimeters; wing, 6.5 to 7.

Female.—Length, about 6 millimeters; wing, 6.

Size medium (wing of male to 7 millimeters); general coloration of thorax yellow, præscutum with ill-defined slightly darker stripes; antennæ brownish black; wings (Plate 1, fig. 17) whitish subhyaline, the veins comprising the cord slightly darker; male hypopygium (Plate 4, fig. 54) with the basistyle, *b*, relatively short and stout, bearing strong apical and basal lobes, the latter with three powerful bristles; two dististyles, *d*, the outer blackened, scabrous; gonapophyses appearing as smooth blackened horns.

CRYPTERIA (FRANCKOMYIA) STYLOPHORA sp. nov.

Plate 1, fig. 16; Plate 4, fig. 55.

Size relatively large (wing of male 7.5 millimeters); general coloration of thorax buffy yellow; halteres and legs yellow, outer tarsal segments brownish black; wings tinged with yellow, veins chiefly yellow, in part blackened; supernumerary crossvein in cell R_3 just distad of R_2; male hypopygium with dististyles subterminal; basistyle with a powerful rod at proximal end of mesal face.

Male.—Length, about 6.5 millimeters; wing, 7.5; antenna, about 1.2.

Rostrum and palpi obscure yellow. Antennæ with scape obscure yellow, pedicel dark brown, flagellum black; flagellar segments elongate, the basal fusion segment comprised of five segments without constrictions or subsegments; free outer segments oval, slightly longer than their verticils, with a short dense white pubescence; terminal segment longer than the penultimate. Front and anterior vertex yellow, remainder of vertex light gray, with long yellow setæ.

Thorax buffy yellow, without distinct pattern. Halteres pale yellow. Legs yellow, the outer tarsal segments brownish black; claws small. Wings (Plate 1, fig. 16) tinged with yellow, the prearcular and costal fields more saturated yellow; veins yellow,

especially in the brightened fields and on proximal third of wing, other veins brownish black, including R, cord, outer end of cell 1st M_2, R_{2+3+4}, base of R_{2+3}, supernumerary crossvein in cell R_3, fork of M_{1+2}, distal section of M_3 and vein 2nd A. Macrotrichia of veins short, occurring on most veins beyond cord, lacking on R_{2+3+4}, basal third of R_{2+3}, proximal end of first section of R_4; basad of cord with trichia on about the outer half of vein 2nd A, lacking on all but outer end of Sc; costal fringe relatively long, especially basally, where some longer yellow setæ are interspersed with the ones. Venation: Sc_1 ending shortly beyond the fork of R_{2+3+4}, Sc_2 about opposite this fork; R_2 short and pale, lying just basad of the supernumerary crossvein in cell R_3, this at about midlength of vein R_4; cell M_1 subequal to its petiole; cell 1st M_2 subequal to or shorter than the distal section of vein M_3; m-cu shortly beyond the fork of M; vein 2nd A of moderate length, arcuated beyond base, thence extended straight to shortly beyond the level of origin of Rs.

Abdomen obscure yellow, hypopygium more intensely yellowed. Male hypopygium (Plate 4, fig. 55) large; basistyle, *b*, long, bent, constricted at near midlength, at apex produced into a large pale flattened lobe that is about equal in length to but broader than the outer dististyle, densely setiferous; at proximal end of basistyle on mesal face with a powerful erect lobe that is tipped with a brush of long yellow setæ; extreme base of style with two separate groups of three or four very long bristles. Dististyles, *d*, subterminal, outer style narrowed at base, much expanded outwardly beneath, the outer angle farther produced into a curved black spine, its surface microscopically scabrous and with tiny setulæ; inner style larger, produced into a dilated outer part that narrows to a point, tipped with two long setæ. Phallosome, *p*, including powerful black gonapophyses, their surface scabrous, and the small simple pale ædeagus.

Habitat.—Sikkim.

Holotype, male, Thomphyak, altitude 12,800 feet, in *Rhododendron* association, May 29, 1959 (*Schmid*).

The only previously described Indian species of the subgenus is *Crypteria* (*Franckomyia*) *recessiva* Alexander (*gracilis* Brunetti, preoccupied), well distinguished from the present fly by the body coloration and more heavily patterned wings. The basic plan of the male hypopygium of the present fly is quite

as in the subgenotype, *Crypteria* (*Franckomyia*) *discalis* Alexander), of western China.

GONOMYIA (PROTOGONOMYIA) AITHOLODES Alexander.
Plate 2, fig. 19; Plate 4, fig. 56.

Gonomyia (*Protogonomyia*) *aitholodes* ALEXANDER, Journ. N. Y. Ent. Soc. 69 (1961) in press.

Type, female, Lingari, Pauri Garhwal, Kumaon, India, altitude 4,400 feet, September 1, 1958 (*Schmid*).

Female.—Length, about 4.5 millimeters; wing, 4.6; antenna, about 1.5.

Size small (wing of female about 4.5 millimeters); general coloration dull brownish black; antennæ, halteres and legs black; wings (Plate 2, fig. 19) tinged with blackish, the prearcular and costal fields slightly more yellowed; veins R_3 and R_4 divergent, narrowing cell R_1 at the margin, cell 2nd M_2 unusually deep; ovipositor (Plate 4, fig. 56) with the cerci narrowly produced at tips.

GONOMYIA (PROTOGONOMYIA) NIGRIPES (Brunetti).

Mesocyphona nigripes BRUNETTI, Fauna Brit. India, Dipt. Nematocera (1912) 458.

Limnophila incompleta BRUNETTI, Rec. Indian Mus. 15 (1918) 326.

The types of the above are from the Darjiling District, North India. The species has been badly confused with several other regional members and is re-described and figured herewith.

Male.—Length, about 5 to 5.5 millimeters; wing, 6 to 6.5.

General coloration black, including the antennæ, halteres and legs; wings (Plate 2, fig. 20) weakly darkened; vein Sc long.

Male hypopygium (Plate 4, fig. 58) with the outer lobe of basistyle, *b*, stout, with a relatively small glabrous apical flange. Three dististyles, *d*, the outer slightly expanded and very obtuse at tip; second style blackened, unequally bifid, its shorter arm an obtuse blade; inner style an elongate blade, the tip obtuse; setæ numerous but small and weak. Ædeagus with a stout apical hook, the expanded central part with numerous long pale setæ.

GONOMYIA (ELLIPTEROIDES) MEOINEURA sp. nov. Plate 2, fig. 21; Plate 4, fig. 57.

Size small (wing of female to 5 millimeters); general coloration black, mesonotal scutellum and dorsopleural region yellow; antennæ, halteres and legs black; wings weakly infuscated, Sc unusually short, Sc_1 ending about opposite one-third the length of Rs; ovipositor with cerci very long and slender; male hypopygium with the outer dististyle terminating in an acute spine;

intermediate style trifid, its longest arm a slender gently curved rod.

Male.—Length, about 3.5 to 3.8 millimeters; wing, 3.8 to 4.2; antenna, about 1.3 to 1.4.

Female.—Length, about 4.8 to 5 millimeters; wing, 4.8 to 5; antenna, about 1.4 to 1.5.

Rostrum and palpi black. Antennæ unusually long, black; flagellar segments long-oval with verticils that exceed the segments. Head black.

Thorax dull black; mesonotal scutellum yellow; dorsopleural membrane obscure yellow, region of the metapleura obscure brownish yellow. Halteres blackened. Legs black. Wings (Plate 2, fig. 21) weakly infuscated; veins darker brown. Macrotrichia on longitudinal veins beyond the general level of origin of Rs, lacking on much of veins Sc, basal section of Cu_1 and the anals. Venation: Sc unusually short, Sc_1 ending about opposite one-third the length of Rs, Sc_2 some distance from its tip; R_{2+3+4} from one-third to one-fourth longer than the basal section of R_5 and about one-half to one-third R_3; outer radial forks only moderately divergent, cell R_2 at margin about one-half as extensive as cell R_3; cell 2nd M_2 about two and one-half to three times its petiole; m-cu at or close to fork of M.

Abdomen brownish black. Ovipositor with valves elongate, especially the very long slender cerci which are acutely pointed at tips. Male hypopygium (Plate 4, fig. 57) with the outer lobe of basistyle, *b*, low and obtuse, with long setæ. Outer dististyle, *d*, expanded on outer half, terminating in an acute spine; intermediate style trifid, the longest arm a slender gently curved rod, its tip acute, axial arm pointed, with long setæ on basal two-thirds, inner arm short, blackened; inner style long-oval, tip obtuse, surface with numerous erect but relatively short setæ, two at apex much longer. Ædeagus, *a*, moderately expanded before the curved apex, the dilated part with long slender setæ.

Habitat.—Sikkim.

Holotype, male, Mangalbarey, altitude 2,800 feet, April 30, 1959 (*Schmid*). Allotopotype, female. Paratopotypes, 4 males and females, one pair still in copula; paratypes, both sexes, Sirwani, altitude 1,150 feet, May 1, 1959 (*Schmid*); 1 male, Dikchu, altitude 2,300 feet, May 9, 1959 (*Schmid*).

Gonomyia (*Ellipteroides*) *meioneura* is told from other regional members of the subgenus having black body coloration and unpatterned wings by the unusually short Sc. The most similar to such species is *G.* (*E.*) *ebenomyia* Alexander, of Nepal, which differs further in the venation, especially of the radial and medial fields.

GONOMYIA (EUPTILOSTENA) MOGHALICA Alexander. **Plate, fig. 22; Plate 5, fig. 59.**

Gonomyia (*Euptilostena*) *moghalica* ALEXANDER, Journ. N. Y. Ent. Soc. 69 (1961) in press.

Type, male, Chhana, Almora, Kumaon, India, altitude 3,500 feet, September 22, 1958 (*Schmid*).

Size medium (wing of male to 6 millimeters); general coloration of head and mesonotum gray, pleura striped with whitish; antennal flagellum dark brown to black; wings (Plate 2, fig. 22) strongly yellowed, restrictedly patterned with brown; male hypopygium (Plate 5, fig. 59) with three dististyles, *d*, the inner one small and slender; ædeagus, *a*, before apex with two small recurved points.

GONOMYIA (IDIOCERA) INVOLUTA Alexander. **Plate 2, fig. 23; Plate 5, fig. 60.**

Gonomyia (*Idiocera*) *involuta* ALEXANDER, Journ. N. Y. Ent. Soc. 69 (1961) in press.

Type, male, Yagtang, Sikkim, altitude 11,650 feet, in *Rhododendron* association, June 17, 1959 (*Schmid*).

Size relatively large (wing of male 7.5 millimeters); mesonotum brown, the præscutum with a central darkening; pleura pale brown with a broad pale-yellow longitudinal stripe; legs light brown; wings (Plate 2, fig. 23) faintly tinged with brown, prearcular and costal fields more yellowed, stigmal darkening small; Sc long, veins R_{1+2} and R_3 nearly contiguous at margin, cell R_3 large; male hypopygium (Plate 5, fig. 60) with apical lobe of basistyle short; three dististyles, the inner and outer ones short, bispinous, blackened, intermediate style longer, including an outer flattened blade and a short black inner basal spine.

GONOMYIA (IDIOCERA) MAGRA sp. nov. **Plate 2, fig. 24; Plate 5, fig. 61.**

Size medium (wing of male to 5.5 millimeters); general coloration of thorax gray, præscutum with two intermediate darker stripes; pleura with a conspicuous light yellow longitudinal stripe; legs brown, outwardly passing into black; wings brownish yellow, prearcular and costal regions clearer yellow, restrictedly patterned with brown; male hypopygium with the intermediate and inner dististyles conspicuously bifid, the outer

style forked shallowly at tip; ædeagus slender, the narrowed tip bent at a right angle.

Male.—Length, about 4.5 to 5 millimeters; wing, 5 to 5.5; antenna, about 1.1 to 1.2.

Female.—Length, about 7 millimeters; wing, 6.

Rostrum and palpi black. Antennæ with proximal three segments yellow, scape more infuscated beneath, remainder of flagellum brownish black to black; flagellar segments oval, shorter than the longest verticils. Head gray, anterior vertex and orbits light yellow.

Pronotum light yellow, brownish gray medially above, pretergites light yellow. Mesonotal præscutum gray with two intermediate brown stripes, widened and slightly divergent behind, pseudosutural foveæ reddish brown; scutum gray, lobes patterned with brown, posterior callosity obscure yellow; scutellum brownish yellow, darker brown at base; postnotum gray, the anterolateral part of mediotergite and dorsal pleurotergite more yellowed. Pleura purplish gray, with a conspicuous light yellow longitudinal stripe extending from behind the fore coxæ to base of abdomen, widened behind; dorsopleural membrane pale yellow. Halteres infuscated. Legs with fore and hind coxæ extensively darkened basally, tips yellow, the middle coxæ more extensively so; trochanters yellow; remainder of legs brown, outer tarsal segments black. Wings (Plate 2, fig. 24) brownish yellow, clearer yellow in prearcular and costal fields; stigma dark brown; a further restricted brown pattern, including small clouds at origin of Rs, cord and m-cu; wing tip in outer ends of cells R_3 and R_5 narrowly darkened; veins brownish yellow, clear yellow in the brightened fields. Macrotrichia on longitudinal veins beyond the general level of origin of Rs, lacking on all but the outer ends of basal sections of M and Cu_1, and on veins 1st A and 2nd A. Venation: Sc moderately long, Sc_1 ending about opposite one-third to one-fifth the length of Rs, Sc_2 before origin of Rs; vein R_3 oblique to suberect, cell R_1 at margin narrow; cell 2nd M_2 nearly twice its petiole; m-cu more than one and one-half times its length before fork of M.

Abdominal tergites dark brown, somewhat paler laterally, posterior borders of segments very narrowly yellow in male, slightly more extensively so in female; hypopygium brownish yellow. Male hypopygium (Plate 5, fig. 61) with apical lobe of basistyle, *b*, slender, with strong setæ. Three dististyles, *d*,

the outer a nearly simple black rod, split at apex into two short unequal spines, surface of basal half scabrous, the outer spine largest; intermediate style unequally bifid, the long very slender outer arm gently sinuous, subequal in length to the base of style, tip narrowly obtuse, inner spine more than half as long, narrowed to the acute tip; inner style very conspicuously bifid, outer arm a long curved spine, exceeding the base in length, narrowed to an acute point, inner spine shorter, straight, with three long setæ at and beyond midlength, with a further concentration of conspicuous bristles on margin near base of spines. Ædeagus, *a*, slender, the narrowed tip bent at about a right angle.

Habitat.—Sikkim.

Holotype, male, Rapham, altitude 5,250 feet, April 2, 1959 (*Schmid*). Allotype, female, Singbeng, altitude 4,920 feet, April 26, 1959 (*Schmid*). Paratype, 1 female, pinned with the allotype.

The specific name, *magra*, is that of an aboriginal tribe in Sikkim. *Gonomyia* (*Idiocera*) *magra* is still another of the regional members of the subgenus having the inner dististyle of the male hypopygium conspicuously bifid. All such species, including also *G.* (*I.*) *maharaja* Alexander, *G.* (*I.*) *myriacantha* Alexander, and *G.* (*I.*) *paleuma* sp. nov., show unusually strong characters in the structure of the hypopygium.

GONOMYIA (IDIOCERA) MAHARAJA Alexander. **Plate 2, fig. 25; Plate 5, fig. 62.**

Gonomyia (*Idiocera*) *maharaja* ALEXANDER, Journ. N. Y. Ent. Soc. 69 (1961) in press.

Type, male, Lata, Pauri Garhwal, Kumaon, India, altitude 7,500 feet, July 6, 1958 (*Schmid*).

General coloration gray, præscutum with two brownish gray intermediate stripes; antennæ with proximal three segments yellow, the remainder darkened; legs obscure yellow, outer tarsal segments black; wings (Plate 2, fig. 25) weakly tinged with yellow, restrictedly patterned with brown; veins R_{1+2} and R_3 narrowly separated at margin; male hypopygium (Plate 5, fig. 62) large and conspicuous; basistyle with apical lobe elongate; three dististyles, all more or less bifid.

GONOMYIA (IDIOCERA) PALEUMA sp. nov. **Plate 2, fig. 26; Plate 5, fig. 63.**

Size medium (wing of male 6 millimeters); mesonotal præscutum with the disk grayish brown, margins broadly yellow; pleura blackened, with a broad yellow longitudinal stripe; legs

yellow, the outer tarsal segments black; wings tinged with yellow, especially the basal and costal regions, with a restricted dark pattern; veins R_{1+2} and R_3 contiguous at margin; male hypopygium with the outer lobe of basistyle relatively long; three dististyles, all bispinous.

Male.—Length, about 5.5 to 5.8 millimeters; wing, 6 to 7.

Rostrum and palpi black. Antennæ with scape and pedicel light yellow, flagellum black; flagellar segments oval, the outer ones more elongate, subequal to the verticils. Head above light yellow on front and orbits, the center of posterior vertex dark brown; vertex with strong black setæ on posterior part.

Pronotum yellow. Mesonotal præscutum with disk almost covered by three confluent grayish brown stripes, the humeral and lateral parts broadly light yellow, pseudosutural foveæ chestnut; scutum brownish gray; scutellum darkened basally, the posterior margin extensively obscure yellow; mediotergite brownish black, pruinose, the anterolateral part yellow, pleurotergite extensively yellowed, darkened on less than the lower half. Pleura blackened, with a broad yellow longitudinal stripe extending from behind the forecoxæ to the abdomen. Halteres pale (apex of knob destroyed). Legs with coxæ light yellow, fore pair slightly darkened at base; trochanters deeper yellow; femora yellow, tips weakly darkened on outer face; tibiæ and tarsi yellowish brown, outer tarsal segments black. Wings (Plate 2, fig. 26) tinged with yellow, the prearcular and costal fields more saturated yellow; stigma small, dark brown; dark brown clouds at origin of Rs, cord and m-cu, darkening the veins, remaining veins yellowed, especially in the brightened fields. Veins beyond cord with strong macrotrichia, with others on Rs and outer ends of Sc, M. Cu_1 and the anals. Venation: Sc moderately long, Sc_1 ending about opposite one-fourth the length of the long Rs, Sc_2 before the origin of the latter; veins R_{1+2} and R_3 contiguous at margin, closing the cell; cell 2nd M_2 about one-half longer than its petiole; m-cu about one and one-half times its length before the fork of M.

Abdomen dark brown, posterior borders of segments obscure yellow, outer segments more uniformly darkened; hypopygium brownish yellow. Male hypopygium (Plate 5, fig. 63) with the apical lobe of basistyle, *b*, relatively slender, narrowed to the subacute tip, with numerous long setæ, especially on lower margin of outer half. Three dististyles, *d*, all bispinous; outer style with spines unequal, the outer long and straight, both

glabrous; intermediate style with the more slender spine gently curved to the acute tip, heavily blackened, outer blade paler, tip obtuse, both arms glabrous; inner style smallest, the spines subequal in length but the outer more slender, inner spine with five strong setæ on margin. Ædeagus, *a*, decurved at tip, the apex produced into a sharp point on lower edge, ventral margin of organ dilated at near two-thirds the length.

Habitat.—Sikkim.

Holotype, male, Lachung, altitude 8,610 feet, July 5, 1959 (*Schmid*). Paratopotype, male, July 9, 1959. Paratype, male, Namnasa, altitude 9,500 feet, July 13, 1959 (*Schmid*).

Readily told from other species of *Idiocera* having all dististyles of the hypopygium bispinous by the structure of the hypopygium.

GONOMYIA (LIPOPHLEPS) DISSIMILIS Alexander. **Plate 2, fig. 27; Plate 5, fig. 64.**

Gonomyia (*Lipophleps*) *dissimilis* ALEXANDER, Journ. N. Y. Ent. Soc. 69 (1961). In press.

Type, male, Perumalmalai, Madras, South India, altitude 4,000 to 4,500 feet, December 6, 1958 (*Schmid*).

General coloration of mesonotum brownish gray, scutellum broadly light yellow; pleura darkened, with a very conspicuous whitened longitudinal stripe; femora yellow with a broad black subterminal ring, posterior pair in male with a series of long erect bristles; wings (Plate 2, fig. 27) marbled with light gray and whitish subhyaline, stigma darker; abdominal tergites dark, the posterior borders broadly yellow; male hypopygium (Plate 5, fig. 64) with two dististyles, the outer very unequally bifid; phallosome with the gonapophyses long and conspicuous, black, dissimilar in form.

GONOMYIA (LIPOPHLEPS) TREPIDA sp. nov. **Plate 5, fig. 65.**

Male.—Length, about 5 millimeters; wing, 4.8.

Very similar to *Gonomyia* (*Lipophleps*) *xanthophleps* sp. nov., differing in the structure of the male hypopygium, particularly the phallosome. Male hypopygium (Plate 5, fig. 65) with the outer dististyle, *d*, long and narrow, slightly longer than the basistyle, at widest part of dilation less than twice the subbasal diameter; inner dististyle very small. Phallosome, *p*, with the gonapophyses dissimilar, subequal in length, one expanded at tip, the outer angle rounded, the inner produced into a short black spine; second apophysis a slender sinuous rod, the apical fourth gradually narrowed to the acute tip.

Habitat.—Sikkim.

Holotype, male, Gangtok, altitude 5,570 feet, May 3, 1959 (*Schmid*).

GONOMYIA (LIPOPHLEPS) XANTHOPHLEPS sp. nov. **Plate 2, fig. 28; Plate 5, fig. 66.**

Belongs to the *nubeculosa* group; general coloration of thorax dark brown, pretergal region, mesonotal scutellum and a pleural stripe conspicuously yellow; femora obscure yellow, with a brownish black subterminal ring preceded and followed by narrow clear yellow annuli; wings with ground darkened, base, costal region and wing apex pale yellow; a restricted darker brown pattern at tip of Sc, stigma, ends of outer radial veins and the cord, cell R_3 present; abdomen brownish black, posterior borders of tergites narrowly obscure yellow; male hypopygium with two dististyles, the outer a broad blackened blade; gonapophyses blackened, dissimilar in form.

Male.—Length, about 4.5 millimeters; wing, 4.8; antenna, about 0.9.

Rostrum and palpi black. Antennæ with scape and pedicel brownish black beneath, conspicuously yellowed above, flagellum black; flagellar segments elongate, with very long verticils, as in the subgenus. Head light-yellow, center of posterior vertex darkened.

Pronotum, extreme lateral margin of præscutum and pretergites light yellow. Mesonotal præscutum and scutum dark brown, scutellum bright yellow, darkened medially at base; postnotum darkened, sparsely pruinose, paling to light brown on pleurotergite and adjoining part of mediotergite. Pleura dark brown, with a very conspicuous longitudinal light yellow stripe extending from and including the forecoxæ, reaching the abdomen; dorsal pleurites, especially the pteropleurite, paler. Halteres with stem light yellow, including the apex of knob, the remainder of latter infuscated. Legs with forecoxæ yellow, remaining coxæ darkened basally, the tips paling to obscure yellow; trochanters yellow; femora obscure yellow with a brownish black subterminal ring that is preceded and followed by a slightly narrower clear yellow annulus; tibiæ obscure yellow; basitarsi brownish yellow, remainder of tarsi black. Wings (Plate 2, fig. 28) with the ground darkened, the prearcular and costal regions pale yellow, interrupted by darkened areas at tip of Sc, stigma and ends of veins R_3 and R_4; other small darkenings at cord and outer end of cell 1st M_2; wing tip in cells R_4 to 2nd M_2 conspicuously yellowish white;

veins light brown, darker in the clouded parts, clear light yellow in the prearcular field and interspaces of veins C, Sc and R. Macrotrichia on most longitudinal veins beyond cord, lacking on second section of M_{1+2} and Cu_1; basad of cord lacking on all veins excepting the extreme outer end of Rs; costal fringe long and conspicuous. Venation: Sc short, Sc_1 ending opposite origin of Rs; vein R_3 very short, suberect; m-cu close to fork of M.

Abdomen brownish black, posterior borders of tergites narrowly obscure yellow; hypopygium with parts of basistyle pale. Male hypopygium (Plate 5, fig. 66) with the tergal lobes low, with long setæ. Dististyles, *d*, two, terminal, the outer a blackened glabrous blade, with less than the outer half narrowed, tip subacute; inner style pale, narrowed outwardly, tipped with two modified setæ. Phallosome with the ædeagus (not figured) depressed-flattened, terminating in a lobe that is fringed with setæ. Gonapophyses asymmetrical, appearing as simple blackened rods, one terminating in a short spine, the other with this much longer and stouter.

Habitat.—West Bengal.

Holotype, male, Pul Bazar, altitude 2,400 feet, March 12, 1959 (*Schmid*).

Other regional members of the *nubeculosa* group include besides *Gonomyia* (*Lipophleps*) *nubeculosa* de Meijere, also *G.* (*L.*) *conjugens* Senior-White, *G.* (*L.*) *pallidosignata* Alexander, and *G.* (*L.*) *trepida* sp. nov., all differing particularly in the structure of the male hypopygium. The male sex of *conjugens* is not known to me but Senior-White's brief statement of "three black linear chitinous processes, one directed posteriorly, two laterally" scarcely appears to pertain to the present fly.

GONOMYIA (GONOMYIA) EMPHYSEMA sp. nov. **Plate 2, fig. 29; Plate 6, fig. 67.**

Size medium (wing of male 5.3 millimeters); mesonotum grayish brown, scutellum yellow; head posteriorly, pronotum and pretergites light yellow; legs black; wings tinged with gray, stigma pale brown; Sc_1 ending about opposite one-third Rs, Sc_2 removed from tip; male hypopygium with outer lobe of basistyle long and slender; both dististyles elongate, the outer with a darkened expansion near midlength; inner style subequal in length, terminating in a black spine; phallosome with two subequal gonapophyses; ædeagus narrowly obtuse at tip, with a further black subtending spine.

Male.—Length, about 5 millimeters; wing, 5.2; antenna, about 1.

Rostrum and palpi black. Antennæ black; proximal flagellar segments oval, beyond the fifth or sixth becoming long-cylindrical, with verticils that are much longer than the segments. Head dark gray, with a light yellow triangle on the posterior vertex.

Pronotum light yellow, vaguely infuscated above, more extensively so on sides; pretergites narrowly light yellow. Mesonotal præscutum and scutal lobes dark grayish brown, central region of scutum restrictedly brightened; scutellum yellow, darkened at base; mediotergite gray, the lateral border narrowly yellow, pleurotergite brownish yellow, slightly darkened on posterior border. Pleura chiefly dark brown, the dorsal sternopleurite and dorsopleural membrane yellowed; posterior pleurites extensively light yellow. Halteres with stem obscure yellow, knob infuscated. Legs with coxæ brown, the posterior pair paler; trochanters yellowish brown; remainder of legs black. Wings (Plate 2, fig. 29) tinged with gray, prearcular and costal fields light yellow; stigma long, pale brown; veins brown, paler brown in the brightened fields. Long macrotrichia on veins beyond the general level of origin of Rs; Sc virtually glabrous, with a few trichia near outer end; approximately the basal third of veins M and 1st A and the basal two-thirds of Cu_1 and 2nd A glabrous. Venation: Sc relatively long, Sc_1 ending about opposite one-third the length of Rs, Sc_2 removed from tip; m-cu about one-fourth its length beyond the fork of M.

Abdomen dark brown, hypopygium more yellowish brown. Male hypopygium (Plate 6, fig. 67) with the outer lobe of basistyle, *b*, long and slender, subequal in length to the body of style, setæ shorter than the lobe. Outer dististyle, *d*, slender on basal half, stouter and with abundant setæ on outer part, at near midlength on inner margin with a conspicuous darkened swelling or extension, its tip obtuse; inner style subequal in length, the outer third narrowed into a black spine, at its base on inner margin dilated, with a concentration of strong setæ, on outer margin at base of spine with a single powerful bristle from a raised tubercle. Phallosome, *p*, including two brown gonapophyses, of approximately equal length, one narrower and extended into a long apical spine, the other broader, its lower margin pale and membranous, tip obtuse; tip of ædeagus darkened, relatively small, apex broadly obtuse, subtended by an outer slender black spine.

Habitat.—Sikkim.

Holotype, male, Lingdok, altitude 4,600 feet, May 7, 1959 (*Schmid*).

Gonomyia (*Gonomyia*) *emphysema* is generally similar to *G.* (*G.*) *affinis* Brunetti and other allied species, differing from all in the structure of the male hypopygium, particularly the dististyles and phallosome.

GONOMYIA (GONOMYIA) ISHANA Alexander. **Plate 2, fig. 30; Plate 6, fig. 68.**

Gonomyia (*Gonomyia*) *ishana* ALEXANDER, Journ. N. Y. Ent. Soc. 69 (1961). In press.

Type, male, Trijugi, Pauri Garhwal, Kumaon, India, altitude 7,000 feet, May 26, 1958 (*Schmid*).

Size large (wing of male 6.5 millimeters); mesonotal præscutum reddish brown with three darker brown stripes, scutellum obscure yellow; pleura reddish brown, striped longitudinally with light yellow; wings (Plate 2, fig. 30) strongly tinged with yellowish brown, the prearcular and costal fields clear yellow; male hypopygium (Plate 6, fig. 68) with the apical lobe of basistyle, *b*, long and slender, with relatively few setæ; outer dististyle, *d*, slender, dilated at apex into a triangle, the angles produced into points; inner style with a strong basal spine; phallosome, *p*, with the apophyses long and slender, acutely pointed and blackened at tips.

GONOMYIA (GONOMYIA) RAVANA sp. nov. **Plate 2, fig. 31; Plate 6, fig. 69.**

Size medium (wing of male under 6 millimeters); general coloration of mesonotal præscutum dark brown, scutellum light yellow; pleura and pleurotergite clear light yellow, restrictedly patterned with brown on propleura and anepisternum; wings strongly suffused with brownish yellow, prearcular and costal regions clearer yellow; Sc relatively short; male hypopygium with three dististyles, the inner bearing a black outer spine and a longer needlelike basal one; phallosome with two blackened apophyses, outer crest relatively small, oval; a recurved black spine beyond the apophyses.

Male.—Length, about 5 millimeters; wing, 5.8.

Rostrum light yellow, palpi black. Antennæ with scape brown, remainder of organ black; basal flagellar segments oval, the outer ones becoming elongate, with long conspicuous verticils. Front and anterior vertex yellow, posterior vertex dark gray.

Pronotum and pretergites clear light yellow. Mesonotal præscutum with disk dark brown, the three usual stripes vir-

tually confluent, humeral and lateral regions light yellow, pseudosutural foveæ chestnut brown; scutal lobes dark brown, central area broadly obscure yellow; scutellum light yellow, the extreme base darkened; mediotergite brownish gray, the anterolateral angles, with the pleurotergite, light yellow. Pleura clear light yellow, the propleura and a major area on anepisternum brown, ventral sternopleurite slightly reddened. Halteres pale yellow. Legs with coxæ clear yellow, trochanters slightly darker yellow; remainder of legs brown, femoral tips infuscated, outer tarsal segments black. Wings (Plate 2, fig. 31) strongly suffused with brownish yellow, prearcular and costal fields, together with basal part of cell Cu, clear yellow; stigma pale brown. Relatively short macrotrichia on veins beyond cord, basad of this with trichia on Rs, more than outer half of M and 1st A, with shorter apical series on Cu_1 and 2nd A; vein Sc glabrous except for a few scattered trichia near outer end. Venation: Sc relatively short, Sc_1 ending about opposite one-fifth the length of Rs, Sc_2 at extreme tip; basal section of R_5 short; cell 1st M_2 subequal in length to vein M_4; m-cu about one-half its length beyond the fork of M.

Abdominal tergites dark brown, sternites and hypopygium yellow. Male hypopygium (Plate 6, fig. 69) with the outer lobe of basistyle, *b*, long and conspicuous, a little larger outwardly, with very abundant setæ, those of outer face longer, of inner margin unusually stout; near base with a compact group of about five stouter pale bristles. Three dististyles, *d*, or branches; outer style longest, very unequally bifid at tip; intermediate style a long slender spine, narrowed to the needlelike tip, beyond midlength with a single powerful bristle; inner style large, at base of outer margin with two spines, the shorter outer one black, the more proximal inner spine longer and pale, subequal in size and shape to the intermediate style; body of style short and stout, terminating in a single powerful bristle, with other more normal setæ on margin and surface. Phallosome, *p*, about as figured, including the crested outer part which bears a strong black spine near its base; two blackened apophyses that are shorter than in decacantha, one more flattened and ribbonlike.

Habitat.—India (Kumaon).

Holotype, male, Gangrea, Pauri Garhwal, altitude 7,500 to 10,000 feet, June 13, 1958 (*Schmid*).

Gonomyia (*Gonomyia*) *ravana* is allied to *G.* (*G.*) *decacantha* Alexander, differing in all details of the male hypopygium, especially the dististyles and phallosome. The blackened spine on the phallosome distal to the apophyses is lacking in *decacantha* but is found in the otherwise quite distinct *G.* (*G.*) *periploca* Alexander.

GONOMYIA (GONOMYIA) SIBYNA sp. nov. **Plate 2, fig. 32; Plate 6, fig. 70.**

Size medium (wing of male about 5.5 millimeters); general coloration of mesonotum dark brown, scutellum yellow; pleura and pleurotergite chiefly yellow; legs brownish black; wings tinged with gray, stigma pale brown, inconspicuous; Sc moderately long, Sc_1 ending opposite or beyond one-third the length of Rs; male hypopygium with the outer dististyle a simple blade, its tip narrowly obtuse; inner style with a single very powerful spine; phallosome with the two gonapophyses unequal, apex of ædeagus pale, obtuse.

Male.—Length, about 5 to 5.2 millimeters; wing, 5.5 to 5.6; antenna, about 0.85 to 0.9.

Rostrum and palpi black. Antennæ black; basal flagellar segments oval, outer ones slender, with long verticils. Head dark brown, restrictedly patterned with obscure yellow.

Pronotum and pretergites light yellow, lateral præscutal margins broadly more obscure yellow. Mesonotal præscutum with disk almost uniformly dark brown; pseudosutural foveæ black; scutal lobes dark brown, the median region yellow; scutellum yellow, darkened medially at base; mediotergite brownish gray, the anterolateral angles light yellow; pleurotergite light yellow, ventral fourth infuscated. Pleura almost uniformly light yellow, the propleura and a weak cloud on anepisternum pale brown; ventral sternopleurite extensively infuscated. Halteres with stem pale, base narrowly yellowed, knob infuscated. Legs with forecoxæ and trochanters brown, of the other legs paler; remainder of legs brownish black. Wings (Plate 2, fig. 32) tinged with gray, the prearcular and costal fields light yellow; stigma pale brown, inconspicuous; veins light brown, those in the brightened areas still paler. Veins of outer two-thirds of wing with conspicuous macrotrichia, lacking on bases of Sc, M, Cu_1 and the anals. Venation: Sc long, Sc_1 ending about opposite one-third to two-fifths Rs, vein R_4 long, deflected caudad, cell R_3 at margin extensive; m-cu at fork of M.

Abdominal tergites dark brown, sternites paler. Male hypopygium (Plate 6, fig. 70) with apical lobe of basistyle, *b*, of moderate length, with long setæ, some nearly as long as the lobe itself. Outer dististyle, *d*, a straight simple rod, slightly widened outwardly, tip narrowly obtuse, the lower outer third glabrous; inner style with a single very powerful spine, gradually curved to the acute tip, outer beak small, with two unequal fasciculate setæ, the lower about twice the size of the upper. Phallosome, *p*, with the two gonapophyses unequal, one long and sinuous; apex of ædeagus pale, obtuse.

Habitat.—Sikkim.

Holotype, male, Dethang, altitude 4,000 feet, April 1, 1959 (*Schmid*). Paratopotype, male.

Gonomyia (*Gonomyia*) *sibyna* is generally similar to other regional species, including *G.* (*G.*) *chalaza* Alexander, differing especially in the structure of the male hypopygium.

GONOMYIA (GONOMYIA) YAMA sp. nov. **Plate 2, fig. 33; Plate 6, fig. 71.**

Size medium (wing over 5 millimeters); general coloration of mesonotal præscutum dark brown, humeral and lateral regions whitish yellow; pleura light yellow, with reddish brown areas on anepisternum and ventral sternopleurite; legs brown, tarsi blackened; wings weakly tinged with brown; macrotrichia of veins long; m-cu close to fork of M; basistyle of male hypopygium with but few setæ; two dististyles, the outer a simple rod, the inner bidentate at apex; phallosome with two blackened unequal apophyses, apex of ædeagal portion obtusely rounded.

Male.—Length, about 4.6 to 4.7 millimeters; wing, 5.2 to 5.4.

Rostrum clear light yellow; palpi black. Antennæ black throughout; outer flagellar segments elongate, shorter than the longest verticils. Head gray.

Pronotum and pretergites clear light yellow. Mesonotal præscutum with disk almost uniformly dark brown, humeral and lateral portions whitish yellow; scutal lobes dark brown, median area and the scutellum obscure yellow, the base of latter restrictedly more darkened; mediotergite brownish gray, the anterolateral border and pleurotergite yellow, the latter more reddened ventrally. Pleura light yellow, variegated on anepisternum and ventral sternopleurite with reddish brown areas. Halteres with stem yellowed, knob moderately infuscated. Legs with coxæ reddened, yellowed at tips; trochanters

obscure yellow; remainder of legs brown, femoral bases more yellowed, tarsi passing into black. Wings (Plate 2, fig. 33) weakly tinged with brown, prearcular and costal fields more yellowed; stigma very faintly darkened; veins dark brown, lighter in the brightened fields. Macrotrichia of veins long, on most longitudinal veins of outer four-fifths of wing, including all of Sc; on M and 1st A narrowly lacking, on Cu_1 and 2nd A more extensively so. Venation: Sc_1 ending about opposite one-fourth to one-fifth the length of Rs, Sc_2 near tip of Sc_1; vein R_4 deflected strongly toward the wing tip, widening cell R_3 at margin; cell 1st M_2 shorter than vein M_4; m-cu at or just before the fork of M.

Abdominal tergites dark brown, sternites yellowed; hypopygium brownish yellow. Male hypopygium (Plate 6, fig. 71) with apical lobe of basistyle, *b*, relatively slender, with few setæ. Two dististyles, *d*, the outer a simple rod with long coarse setæ, on mesal face at midlength with a long glabrous flange; inner style shorter, near apex with two nearly equal points or teeth, at their base with the long apical setæ. Phallosome, *p*, with two blackened unequal apophyses, ædeagus dilated and obtusely rounded at apex.

Habitat.—Kumaon.

Holotype, male, Gangrea, Pauri Garhwal, altitude 7,500 to 10,000 feet, June 15, 1958 (*Schmid*). Paratype, male, Khati, Almora, altitude 7,700 to 8,000 feet, September 10, 1958 (*Schmid*).

Gonomyia (*Gonomyia*) *yama* is quite distinct from all of the now numerous regional species of the subgenus in the structure of the male hypopygium, particularly the dististyles. The hypopygium is much simpler than that of various species allied to *G.* (*G.*) *decacantha* Alexander, especially in the structure of the inner dististyle and phallosome.

LIPSOTHRIX MIRIFICA sp. nov. **Plate 2, fig. 34; Plate 6, fig. 72.**

General coloration black; antennæ of male elongate; wings brownish yellow, patterned with pale brown, especially over the cord; R_{2+3+4} short, only about one-third longer than the basal section of R_5; cell 1st M_2 very large, rectangular, subequal in length to distal section of M_{1+2}; male hypopygium with the interbase long and slender, strongly bent beyond midlength.

Male.—Length, about 8 to 8.2 millimeters; wing, 9 to 9.5; antenna, about 3 to 3.1.

Rostrum and palpi dark brown. Antennæ of male elongate, about one-third the wing, dark brown; flagellar segments with a short dense pale pubescence, additional to the sparse verticils, the latter shorter than the segments; terminal segment oval, only about one-third as long as the penultimate. Head black.

Thorax black, præscutum with sparse erect setæ. Halteres obscure brownish yellow. Legs with coxæ black; trochanters yellow; femora brown, the bases yellowed; tibiæ and tarsi brown; each claw with two conspicuous spines, the outer one longer. Wings (Plate 2, fig. 34) brownish yellow, the prearcular field yellow, costal region less evidently so; broad pale brown seams over cord and outer end of cell 1st M_2, much narrower at fork of Sc and on R_2; a darkened cloud in cell Cu_1 between the cubital branches; veins brown, yellowed in the brightened fields. Macrotrichia on longitudinal veins beyond cord, outer half of Sc and outer ends of anal veins, the latter very sparse, including a single trichia on 1st A and about four on 2nd A. Venation: Sc_1 ending about opposite two-thirds the length of R_{2+3+4}, the latter short, only about one-third longer than basal section of R_5; cell 1st M_2 very large, rectangular, subequal in length to distal section of M_{1+2}; m-cu shortly beyond fork of M.

Abdomen, including hypopygium, black. Male hypopygium (Plate 6, fig. 72) with the outer dististyle, *d*, shorter than the inner; interbase, *i*, with proximal end dilated, thence unusually long and slender, beyond midlength bent at nearly a right angle, outwardly slightly expanded into a narrow blade, the tip acute.

Habitat.—Sikkim.

Holotype, male, Chachu, altitude 9,950 feet, in *Rhododendron* association, May 17, 1959 (*Schmid*). Paratype, male, Gey, altitude 11,650 feet, in *Rhododendron* association, May 18, 1959 (*Schmid*).

Lipsothrix mirifica is quite distinct from all other regional species in its black coloration, patterned wings and venation. It is most like *L. mirabilis* Alexander, of western China, differing conspicuously in the pattern and venation of the wings.

HESPEROCONOPA SIKKIMENSIS sp. nov. . . **Plate 2, fig. 35; Plate 6, fig. 73.**

General coloration dark gray, præscutum with a darker central stripe that is narrowly bordered by blackish; antennæ and

legs black; wings strongly blackened; male hypopygium with mesal face of basistyle with abundant setæ, the outer ones more spinoid; both the interbase and gonapophysis blackened and pointed at tips.

Male.—Length, about 4.2 to 5 millimeters; wing, 4.6 to 5.8; antenna, about 1.2 to 1.4.

Female.—Length, about 4.8 to 5.2 millimeters; wing, 5.5 to 6.2.

Rostrum and palpi black. Antennæ black throughout; first flagellar segment oval, the succeeding ones short-oval, becoming progressively smaller outwardly; segments with a dense pale pubescence, the sparse verticils shorter than the segments. Head dark gray; anterior vertex broad.

Pronotum brownish gray. Mesonotal præscutum gray, with a darker gray central stripe that is narrowly bordered by blackish, præscutal borders narrowly darkened, the interspaces with conspicuous erect black setæ; posterior sclerites of notum blackened, sparsely pruinose; scutal lobes and scutellum with black setæ. Pleura and pleurotergite clear light gray, glabrous. Halteres with stem light brown, especially at base, knob dark brown. Legs with coxæ and trochanters blackened; remainder of legs black, femoral bases narrowly obscure yellow; vestiture short. Wings (Plate 2, fig. 35) strongly blackened; veins black. Veins with strong macrotrichia, lacking at bases of M, Cu_1 and the anals. Venation: Sc_1 ending about opposite one-half to nearly two-thirds the length of R_{2+3+4}, Sc_2 about opposite or before the fork of Rs; R_2 shorter than R_{2+3}; m-cu at or close to fork of M.

Abdomen blackened, pruinose to appear dark gray. Ovipositor with cerci long, blackened basally, upcurved to the acute tips. Male hypopygium (Plate 6, fig. 73) with basistyle, *b*, stout, its mesal face with abundant setæ, the more cephalic ones very long and delicate, outer ones becoming strong and spinoid; outer face of style with fewer normal setæ. Outer dististyle, *d*, with microscopic setulæ only, to appear nearly glabrous; apex obtuse, the lateral spine at near midlength blackened, relatively weak; inner style shorter, tip obtuse, outer surface with strong erect to slightly retrorse setæ. Interbasal rods enlarged basally, the outer half narrowed into a black spine, its tip acute. Phallosome, *p*, with the ædeagus slender, small, pale yellow; apophyses appearing as slender black spines.

Habitat.—Sikkim.

Holotype, male, Zema, altitude 8,900 feet, May 24, 1959 (*Schmid*). Allotopotype, female, pinned with type. Paratopotypes, males and females, with types; paratypes, males and females, Yedang, altitude 9,680 feet, June 10, 1959 (*Schmid*).

The discovery of a species of the genus *Hesperoconopa* Alexander in Asia is of unusual interest, all other known species being from western North America. In its general appearance the fly suggests a large species of *Bæoura* from which it readily is told by the very different genitalia of both sexes.

CHEILOTRICHIA (CHEILOTRICHIA) GLORIOLA sp. nov. Plate 2, fig. 36; Plate 6, fig. 74.

Size medium (wing of male 5 millimeters); general coloration polished black, head more pruinose; antennæ and legs black, femoral bases restrictedly yellow; halteres yellow; wings tinged with yellow, the base and costal region strongly so, with a restricted brown pattern; cell 1st M_2 closed; male hypopygium with the outer dististyle bifid, its inner arm shallowly notched at tip.

Male.—Length, about 4.5 millimeters; wing, 5.

Female.—Length, about 5.5 millimeters; wing, 5.6.

Rostrum, palpi and antennæ black; flagellar segments of male oval, with very long verticils. Head dark gray.

Pronotum dull black, sides obscure yellow, the pretergites narrowly of the same color, more conspicuously so before the wing root. Mesonotum black, surface shiny, with a very faint gray pruinosity; a few long yellow bristles. Pleura more pruinose, especially ventrally. Halteres pale yellow. Legs with the coxæ black; trochanters yellowish brown; remainder of legs black, femoral bases yellowed, narrowly so on forelegs, more evident on posterior pair where, in cases, about the proximal seventh is included; legs without scales. Wings (Plate 2, fig. 36) tinged with yellow, more saturated and conspicuous at base, including veins Sc, R, and all but the tips of the anals; a restricted but conspicuous brown pattern, including seams at cord and outer end of cell 1st M_2, R_2 and R_{1+2}, and outer two-thirds of vein Cu, best evidenced by a deepening in color of the veins. Veins of outer two-thirds of wings with macrotrichia, lacking on base of Sc, most of M, and the very restricted bases of anal veins. Venation: Sc very long, Sc_1 ending shortly before level of fork of the long Rs, Sc_1 about twice R_2; R_{2+3+4} subequal to R_{3+4}; cell 1st M_2 closed, a little

shorter than distal section of vein M_3; m-cu at or close to fork of M.

Abdomen black. Ovipositor with valves horn yellow, long and very slender, nearly straight. Male hypopygium (Plate 6, fig. 74) with basistyle, *b*, short and compact, without apical lobes. Dististyles, *d*, terminal, both blackened; outer style deeply bifid, the arms nearly parallel to one another, outer arm simple, subequal in length to the base, inner arm shorter and more slender, shallowly and unequally bidentate at tip; inner style a simple flattened blade, tip obtuse, lower margin with a flange. Ædeagus, *a*, slender, from a rectangular basal plate.

Habitat.—Sikkim.

Holotype, male, Talam, altitude 11,300 feet, in *Rhododendron* association, June 16, 1959 (*Schmid*). Allotype, female, Chachu, altitude 9,500 feet, in *Rhododendron* association, May 21, 1959 (*Schmid*).

Cheilotrichia (*Cheilotrichia*) *gloriola* is the first representative of the typical subgenus to be found in India. It is readily told from the now numerous species of the subgenus *Empeda* Osten Sacken by the polished black coloration, wing pattern, and closed cell 1st M_2.

RHABDOMASTIX (RHABDOMASTIX) HIMALAYENSIS Alexander.
Plate 2, fig. 37; Plate 6, fig. 75.

Rhabdomastix (*Rhabdomastix*) *himalayensis* ALEXANDER, Journ. N. Y. Ent. Soc. 68 (1960) in press.

Type, male, Salkhola, Pauri Garhwal, Kumaon, altitude 4,240 feet, August 22, 1958 (*Schmid*).

Male.—Length, about 7 millimeters; wing, 7.2; antenna, about 26.

Size large (wing of male about 7 millimeters); antennæ of male very long, exceeding three times the body or wing; general coloration of thorax dark grayish brown; femora obscure yellow, narrowly darkened at tips; wings (Plate 2, fig. 37) very weakly darkened, unpatterned except for the darker brown stigma; veins unusually glabrous; Sc long, anal cells very broad; male hypopygium (Plate 6, fig. 75) with the interbase, *i*, elongate, narrowed very gradually into a hairlike point.

RHABDOMASTIX (SACANDAGA) ALMORÆ Alexander. Plate 2, fig. 38; Plate 6, fig. 76.

Rhabdomastix (*Sacandaga*) *almoræ* ALEXANDER, Journ. N. Y. Ent. Soc. 68 (1960) in press.

Type, male, Bagheswar, Almora, Kumaon, altitude 3,200 feet, September 23, 1958 (*Schmid*).

Size small (wing, 4 millimeters or less); general coloration of head and thorax gray, the præscutum with indications of a pair of pale brown stripes; legs brownish black; wings (Plate 2, fig. 38) relatively narrow, membrane weakly darkened; macrotrichia of veins reduced in number; Sc relatively long, cell 2nd A narrow; male hypopygium (Plate 6, fig. 76) with the outer half of the interbase, *i*, a long pale blade.

(In an earlier part of this series of papers an error was made that should be corrected. In Part XLV [Philip. Journ. Sci. 86 (1957) 429] two species with the identical name, *Eupilaria singhalica*, were described. The second of these actually was named *Eupilaria taprobanica* Alexander, as is evident elsewhere in the same report.)

REFERENCES

1. Alexander, C. P. The Oriental Tipulidæ in the collection of the Indian Museum. Part II. Rec. Indian Mus. 44 (1942) 29–72.

2. Alexander, C. P. New or little-known Tipulidæ (Diptera), XCI. Oriental–Australasian Species. Ann. Mag. Nat. Hist. (12) 4 (1951) 1072–1102.

3. Brunetti, E. The fauna of British India, including Ceylon and Burma. (Taylor and Francis, London, 1912) 581 pp., 12 pls., 44 figs.

4. Brunetti, E. Diptera of the Simla District. Rec. Indian Mus. 13 (1917) 59–101, 4 figs.

5. Edwards, F. W. Notes on the types of Diptera Nematocera (Mycetophilidæ and Tipulidæ) described by Mr. E. Brunetti. Rec. Indian Mus. 26 (1924) 291–307.

6. Edwards, F. W. Some Nematocerous Diptera from Yunnan and Tibet. Ann. Mag. Nat. Hist. (10) 1 (1928) 681–703, 1 pl.

7. Gressitt, J. Linsley. Notes on collecting in Formosa. The Entomological World (Tokyo) 4 (1936) 711–727.

8. Hingston, R. W. G. A naturalist in Himalaya (Witherby, London, 1920) 300 pp., map, 24 pls, figs.

9. Hooker, Joseph Dalton. Himalayan Journals; or, notes of a naturalist in Bengal, the Sikkim and Nepal Himalayas, the Khasia mountains, etc. (John Murray, London, 1954) 1: 1–xxiv, 1–408, 5 col. liths., 45 wood engravings, 2 maps; 2: 1–xii, 1–487, 7 col. liths., 35 wood engravings.

10. Kapur, A. P. High altitude insects of the Himalayas. Proc. Tenth Internat. Congr. Ent. (1956) 1: 775–784, 1 map. 5 figs.

11. Lyde, Lionel, W. The continent of Asia (Macmillan, London) 777 pp., 143 figs.

12. MANI, M. S. Entomological survey of the Himalayas. I. Introduction, description of gall midges (Itonididæ–Cecidomyiidæ: Diptera) and plant galls from the western Himalayas. Agra Univ. Journ. Res. (Science), pt. 1 3 (1954) 13–42, 10 pls., 36 figs.

13. MANI, M. S. Entomological survey of the Himalayas. 4. Expedition to the Upper Chenab Valley—1954. Agra Univ. Journ. Res. (Science), pt. 1 4 (1955a) 157–170, 1 map, 13 pls., 2 figs.

14. MANI, M. S. Entomologists in the Himalayas. Turtox News (1) 33 (1955b) 2–5, 2 figs.

15. MANI, M.S. Second entomological expedition to the north-west Himalayas. Turtox News (1) 34 (1956) 2–5, 3 figs.

16. MANI, M. S., and SANTOKH SINGH. Entomological survey of the Himalayas. Part 13. Second entomological expedition to north-west (Punjab) Himalayas (1955). Agra Univ. Journ. Res. (Science), Suppl. 4 (1955) 717–740, 2 pls., 17 figs.

17. PRASHAD, BAINI (as B. P.) Enrico Brunetti. Obituary Notice. Rec. Indian Mus. 29 (1927) 287–290.

18. SENIOR–WHITE, RONALD (as R. S.–W.). Brunetti as a Dipterologist. Rec. Indian Mus. 29 (1927) 290–296.

19. SINGH, SANTOKH. The third entomological expedition to the north-west Himalaya. Turtox News 35 (1957) 170–173, 3 figs.

20. SMYTHE, F. S. The Kanchenjunga Adventure (Gollancz, London, 1930) 464 pp., 48 pls.

21. WARD, F. KINGDON. Plant hunting on the edge of the world (Gollancz, London, 1930) 383 pp., 16 pls.

22. WARD, F. KINGDON. A plant hunter in Tibet (Jonathan Cape, London, 1934) 317 pp., 2 maps, 19 pls.

23. WARD, F. KINGDON. Plant hunter's paradise (Jonathan Cape, London, 1927) 347 pp., 2 maps, 13 pls.

ILLUSTRATIONS

[Legend: *a*, ædeagus; *b*, basistyle; *g*, gonapophysis; *i*, interbase; *p*, phallosome; *s*, sternite; *t*, tergites.]

Plate 1

Fig. 1. *Macgregoromyia sikkimensis* sp. nov.; venation.
2. *Dolichopeza* (*Mitopeza*) *amisca* sp. nov.; venation.
3. *Dolichopeza* (*Nesopeza*) *ballator* sp. nov.; venation.
4. *Dolichopeza* (*Nesopeza*) *præsul* sp. nov.; venation.
5. *Protohelius nilgiricus* Alexander; venation.
6. *Lechria coorgensis* Alexander; venation.
7. *Nasiternella tjederi* sp. nov.; venation.
8. *Pedicia* (*Tricyphona*) *sakkya* sp. nov.; venation.
9. *Dicranota* (*Rhaphidolabina*) *magra* sp. nov.; venation.
10. *Dicranota* (*Rhaphidolabina*) *megomma* sp. nov.; venation.
11. *Dicranota* (*Rhaphidolabina*) *niphas* sp. nov.; venation.
12. *Dicranota* (*Amalopina*) *elegantula* (Brunetti); venation.
13. *Limnophila* (*Elæophila*) *delicola* sp. nov.; venation.
14. *Eupilaria uma* sp. nov.; venation.
15. *Hexatoma* (*Eriocera*) *glomerosa* Alexander; venation.
16. *Crypteria* (*Crypteria*) *basistylata* Alexander; venation.
17. *Crypteria* (*Crypteria*) *haploa* Alexander; venation.
18. *Crypteria* (*Franckomyia*) *stylophora* sp. nov.; venation.

Plate 2

Fig. 19. *Gonomyia* (*Protogonomyia*) *aitholodes* Alexander; venation.
20. *Gonomyia* (*Protogonomyia*) *nigripes* (Brunetti); venation.
21. *Gonomyia* (*Ellipteroides*) *meioneura* sp. nov.; venation.
22. *Gonomyia* (*Euptilostena*) *moghalica* Alexander; venation.
23. *Gonomyia* (*Idiocera*) *involuta* Alexander; venation.
24. *Gonomyia* (*Idiocera*) *magra* sp. nov.; venation.
25. *Gonomyia* (*Idiocera*) *maharaja* Alexander; venation.
26. *Gonomyia* (*Idiocera*) *paleuma* sp. nov.; venation.
27. *Gonomyia* (*Lipophleps*) *dissimilis* Alexander; venation.
28. *Gonomyia* (*Lipophleps*) *xanthophleps* sp. nov.; venation.
29. *Gonomyia* (*Gonomyia*) *emphysema* sp. nov.; venation.
30. *Gonomyia* (*Gonomyia*) *ishana* Alexander; venation.
31. *Gonomyia* (*Gonomyia*) *ravana* sp. nov.; venation.
32. *Gonomyia* (*Gonomyia*) *sibyna* sp. nov.; venation.
33. *Gonomyia* (*Gonomyia*) *yama* sp. nov.; venation.
34. *Lipsothrix mirifica* sp. nov.; venation.
35. *Hesperoconopa sikkimensis* sp. nov.; venation.
36. *Cheilotrichia* (*Cheilotrichia*) *gloriola* sp. nov.; venation.
37. *Rhabdomastix* (*Rhabdomastix*) *himalayensis* Alexander; venation.
38. *Rhabdomastix* (*Sacandaga*) *almoræ* Alexander; venation.

PLATE 3

FIG. 39. *Macgregoromyia sikkimensis* sp. nov.; male hypopygium.
40. *Dolichopeza* (*Mitopeza*) *amisca* sp. nov.; male hypopygium.
41. *Dolichopeza* (*Nesopeza*) *præsul* sp. nov.; male hypopygium.
42. *Tipula* (*Bellardina*) *arjuna* sp. nov.; male hypopygium.
43. *Tipula* (*Bellardina*) *krishna* sp. nov.; male hypopygium.
44. *Tipula* (*Bellardina*) *hypsistos* sp. nov.; male hypopygium.
45. *Protohelius nilgiricus* Alexander; male hypopygium.
46. *Nasiternella grallator* sp. nov.; antenna, male hypopygium.
47. *Nasiternella tjederi* sp. nov.; male hypopygium.
48. *Pedicia* (*Tricyphona*) *sakkya* sp. nov.; male hypopygium.

PLATE 4

FIG. 49. *Dicranota* (*Rhaphidolabina*) *magra* sp. nov.; male hypopygium.
50. *Dicranota* (*Rhaphidolabina*) *megomma* sp. nov.; male hypopygium.
51. *Dicranota* (*Rhaphidolabina*) *niphas* sp. nov.; male hypopygium.
52. *Dicranota* (*Amalopina*) *elagantula* (Brunetti); male hypopygium.
53. *Crypteria* (*Crypteria*) *basistylata* Alexander; male hypopygium.
54. *Crypteria* (*Crypteria*) *haploa* Alexander; male hypopygium.
55. *Crypteria* (*Franckomyia*) *stylophora* sp. nov.; male hypopygium.
56. *Gonomyia* (*Protogonomyia*) *aitholodes* Alexander; ovipositor.
57. *Gonomyia* (*Ellipteroides*) *meioneura* sp. nov.; male hypopygium.
58. *Gonomyia* (*Photogonomyia*) *nigripes* (Brunetti); male hypopygium.

PLATE 5

FIG. 59. *Gonomyia* (*Euptilostena*) *moghalica* Alexander; male hypopygium.
60. *Gonomyia* (*Idiocera*) *involuta* Alexander; male hypopygium.
61. *Gonomyia* (*Idiocera*) *magra* sp. nov.; male hypopygium.
62. *Gonomyia* (*Idiocera*) *maharaja* Alexander; male hypopygium.
63. *Gonomyia* (*Idiocera*) *paleuma* sp. nov.; male hypopygium.
64. *Gonomyia* (*Lipophleps*) *dissimilis* Alexander; male hypopygium.
65. *Gonomyia* (*Lipophleps*) *trepida* sp. nov.; male hypopygium.
66. *Gonomyia* (*Lipophleps*) *xanthophleps* sp. nov.; male hypopygium.

PLATE 6

FIG. 67. *Gonomyia* (*Gonomyia*) *emphysema* sp. nov.; male hypopygium.
68. *Gonomyia* (*Gonomyia*) *ishana* Alexander; male hypopygium.
69. *Gonomyia* (*Gonomyia*) *ravana* sp. nov.; male hypopygium.
70. *Gonomyia* (*Gonomyia*) *sibyna* sp. nov.; male hypopygium.
71. *Gonomyia* (*Gonomyia*) *yama* sp. nov.; male hypopygium.
72. *Lipsothrix mirifica* sp. nov.; male hypopygium.
73. *Hesperoconopa sikkimensis* sp. nov.; male hypopygium.
74. *Cheilotrichia* (*Cheilotrichia*) *gloriola* sp. nov.; male hypopygium.
75. *Rhabdomastix* (*Rhabdomastix*) *himalayensis* Alexander; male hypopygium.
76. *Rhabdomastix* (*Sacandaga*) *almoræ* Alexander; male hypopygium.

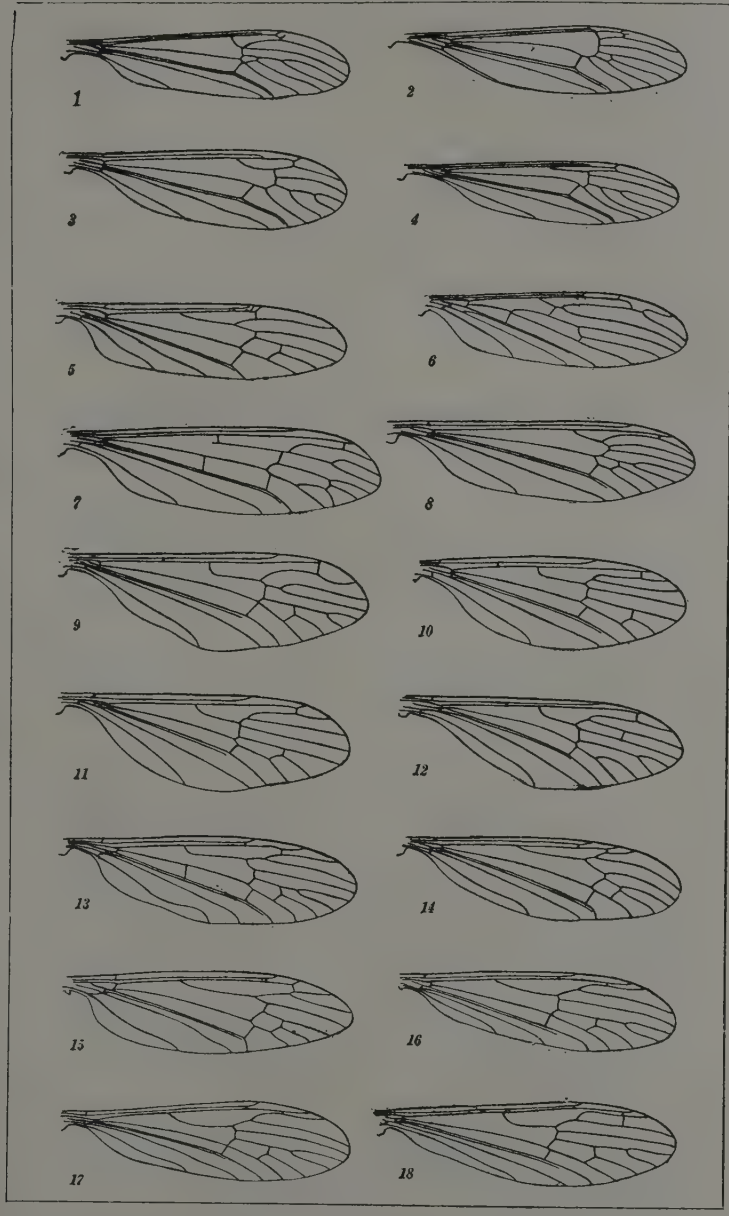


PLATE 1.

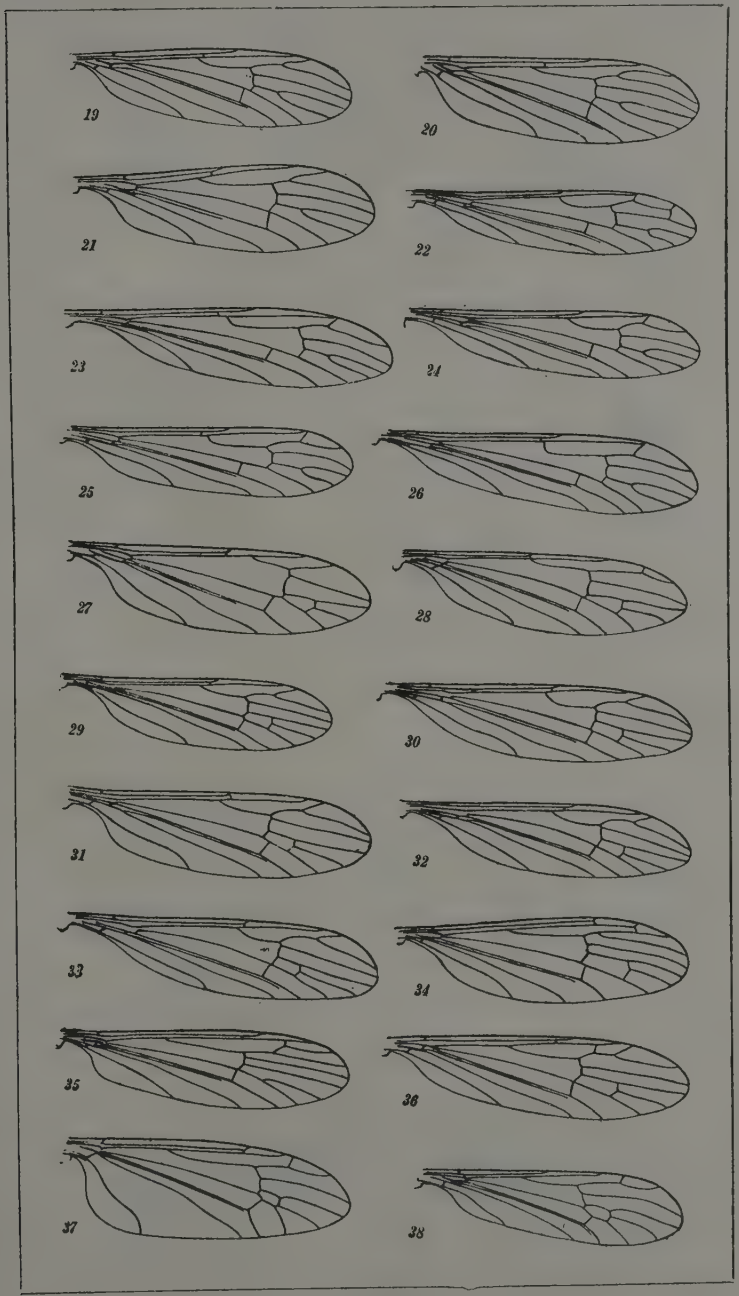
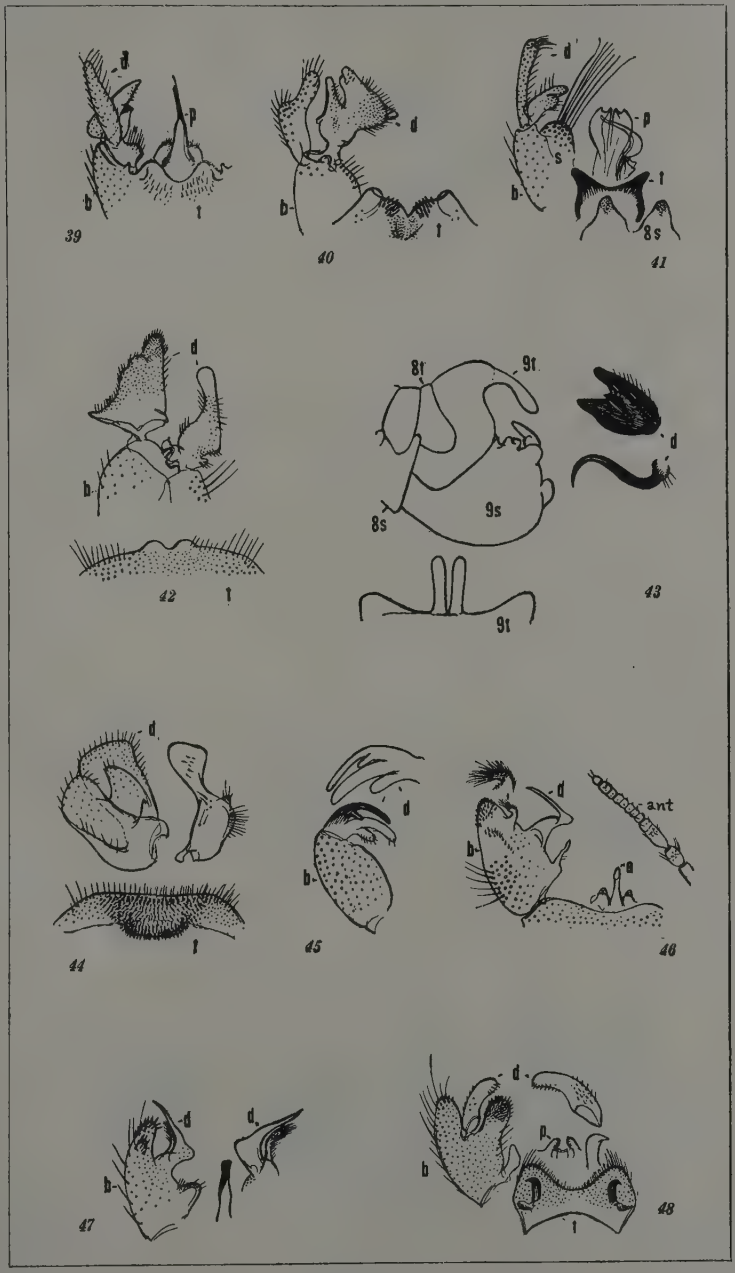


PLATE 2.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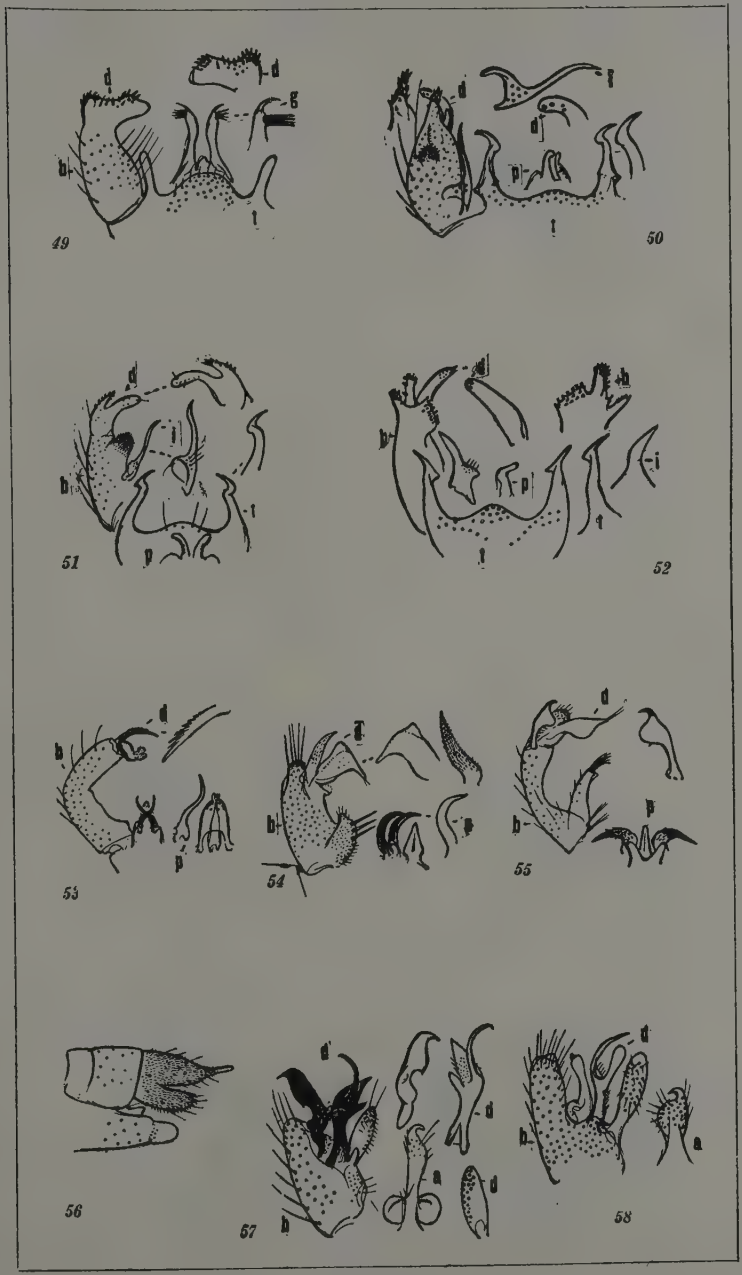

PLATE 4.

PLATE 5.

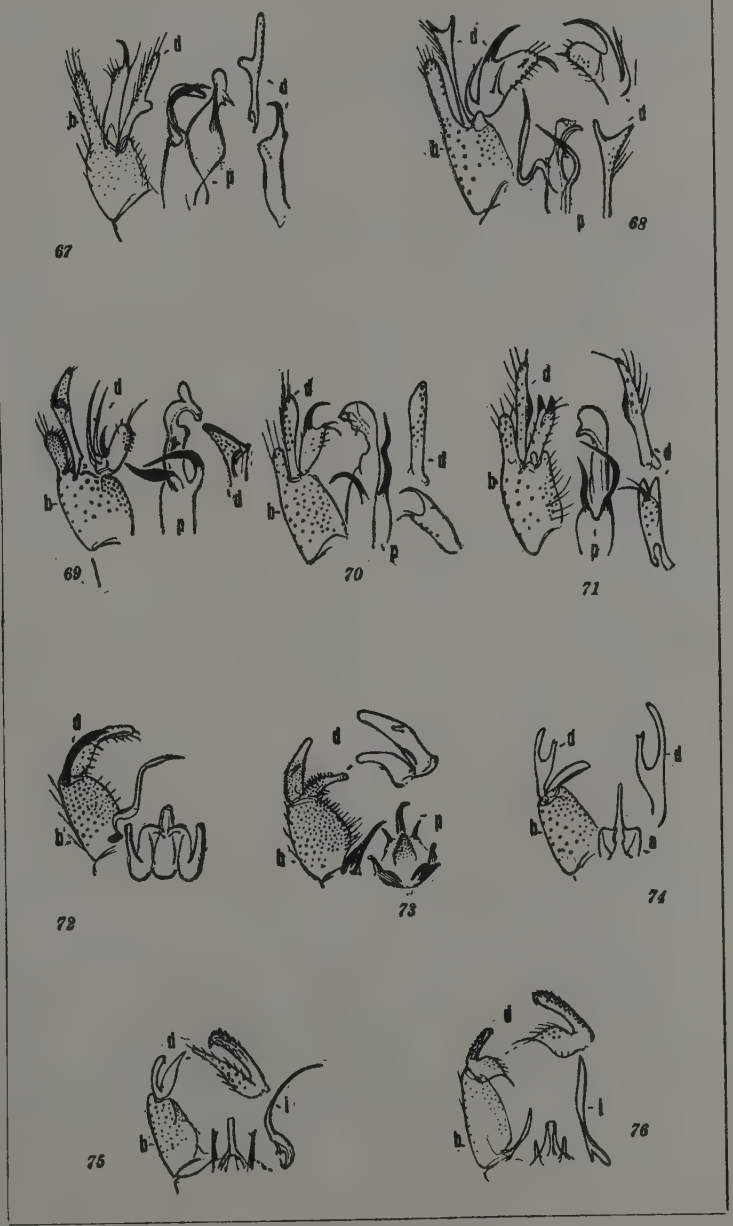

PLATE 6.

PROBABLE RELATION TO ALTITUDE OF THE MOUND-BUILDING HABIT OF MACROTERMES (ISOPTERA: TERMITIDÆ)

By Leopoldo B. Uichanco

Termites of the higher phylogenetic groups, particularly members of the subfamily Macrotermitinæ, have been known for their propensity to construct their nests in the form of more or less sizable earthen mounds. In the Philippines, these termite mounds, locally called *punso*, are a characteristic feature of the low- and middle-altitude landscape. The casual observer cannot but notice them along roadsides, open fields, orchards and cut-over forest areas, where the mounds of the older colonies reach a height of about a meter or over from the base. Their interesting details have been studied and discussed by several previous authors, of which the most recent was the careful observation made in Indonesia by Kalshoven.(3, 4, 5)

Because it is not the object of the present paper, I shall make no attempt to supply additional information beyond remarking in passing that the compact outer wall and inner earthen structures of the mound partake of the characteristics of the surface layer of the surrounding land. This fact indicates that the earthen components of the nest are presumably derived with little modification from that source. Hence, in Tarlac Province, Central Luzon, the mound walls are light-colored and the clay admixed with fine silt characteristic of the alluvial soil of that area, in contrast with the darker and more clayey walls on the mounds formed on the volcanic soils of Laguna and Batangas Provinces, in Southern Luzon. Hitherto, only one mound-building species has been recorded from the Philippines, *Macrotermes gilvus* Hagen, which likewise has been the only representative of that genus known in this country. In addition to the Philippines, *M. gilvus* also occurs in most other countries of the Indo-Malaysian Region—Malaya, Indo-China, Berneo, Sumatra, Java, and probably other islands in the neighborhood. According to Dammerman,(1) this species "is distributed from the Malay Peninsula and the Greater Sunda Islands as far eastwards as Celebes and Timor."

The present paper reports an interesting occurrence of *Macrotermes gilvus* [1] on the grounds of the Philippine Military Academy Reservation at Loakan, Baguio, at an elevation of about 1,300 meters. On January 30, 1953, while making an excavation for a building site, the laborers accidentally dug up an underground colony, from which my brother, Col. Conrado B. Uichanco, of the Inspector General's staff, collected a queen with the abdomen greatly distended with eggs, a king, a small soldier, and a worker. Because he was not prepared for entomological collecting, he was unable to save more material; for that matter, he had to go to a considerable trouble looking for a specimen bottle and preservative. According to him, there was no mound to mark the site of the nest. As a matter of fact, in my various field trips in Baguio and the rest of the high elevations of the Mountain Province, I have never come across any, which probably indicates that at high mountain altitudes *Macrotermes gilvus* nests strictly below ground level. Hence, the colonies are very difficult to locate, except by chance.

The species is probably not uncommon in the Baguio area. During my almost annual visits there, usually in May or June, I frequently noticed attracted to light swarms of winged adults of apparently the same form. Until the present collection of the Loakan material, I had mistakenly assumed that *Macrotermes* did not settle down in colonies in the Mountain Province but that the winged swarms were fortuitously carried up by wind currents from the lower altitudes of Pangasinan or La Union. With this new finding, it would now be reasonable with certainty to connect these swarms with resident sources. For that matter, Snyder,(7) (and in a letter, December 3, 1959) stated that the late Dr. Sol F. Light had given him the general information that "In the Philippines . . . no mounds built by *Odontormes* [also of the Termitidæ] occur, whereas mounds inhabited by *Macrotermes* are a conspicuous element of the landscape in the lowlands: In the highlands, no mounds occur; the termites have probably gone underground because of temperature requirements." Earlier, Light,(6) in recording *Macrotermes barneyi* Light, collected by Miss Katherine L. Schaeffer from the southern part of Hainan Island, remarked that "*Macrotermes gilvus* Hagen, a closely related species,

[1] Identification verified by Dr. Thomas E. Snyder, U. S. National Museum, where the specimens have been deposited.

builds conspicuous mounds in the Philippines and East Indian Islands. No such mounds have been reported from China as yet. They may be expected to be in the more southern portion of the range of the species." Hainan is, of course, well within the tropics, but it is quite possible, although she did not mention the fact, that Miss Schaeffer had obtained her material from a high collection locality.

One intriguing question is, why the difference in nesting habit between the lowland and the upland forms. Emerson,(2) in explaining the ecological function of the nest of *Natutitermes corniger* on Barro Colorado Island, concludes, after a series of hourly thermometric observations through a daily cycle between September 2 and 3, 1935, that "(*1*) the direct sun rays on the nest raise the internal temperature above the shade temperature of the surroundings, and (*2*) that the temperatures follow the daily rhythm of the external temperatures, but lie behind the rising and falling external temperatures and do not reach the extremes found outside the nest which reached maximum above 120° F [49° C] (the limit of the thermometers available) were far in excess of any internal nest temperatures, and the nest temperatures measured above the maximum shade temperatures were doubtless due to the direct rays of the sun." The same tempering effect of the mounds of *Macrotermes gilvus* doubtless also occurs in the sizzling heat of the lowlands, where the shade temperature in the early afternoons describes a mean of 38° C. Some of the largest mounds I have seen were in Tarlac Province, in which vicinity the record temperature for the Philippines of 42.2° C was reported. The mound, especially when exposed to the sun, would serve to reduce these extremes of high temperature within the walls. In the high altitude of Baguio, on the other hand, extreme heat is never experienced, with the mean maximum temperature of 26.6° C, while the night temperature averages 8.8° C and never reaches freezing. What is more, the sky in the Baguio area is thickly blanketted by clouds a great deal of the time, so that the termite nests would not be constantly subjected to direct exposure to the sun.

At first blush, one could be tempted to explain the presence of mounds as a protection against flooding of the termite nest during heavy precipitation. However, this premise will not find support in the fact that the average annual rainfall in the lowlands, where termite mounds occur, is only about 2,000 mm, while that in Baguio, where these mounds are apparently non-

existent, it is 4,597.6 mm. Incidentally, Baguio holds the world record for rainfall in twenty-four hours—1,168.1 mm.

Another possible explanation is the absence in the Baguio area of such aggressive natural enemies as the fire ant, *Solenopsis geminata* Fabricius. In the lowlands, this ant not infrequently camps at the base of termite mounds and attacks termite individuals that happen to be accidentally exposed, such as when the hard protecting wall of the mound is broken.

REFERENCES

1. Dammerman, K. W. The Agricultural Zoology of the Malay Archipelago. J. H. de Bussy, Ltd., Amsterdam (1929) xi+473 p.

2. Emerson, Alfred E. Termite nests—a study of the phylogeny of behavior. Ecol. Mono. 8 (1938) 247–284.

3. Kalshoven, L. G. E. Observations on Macrotermes gilvus Holmgr. in Java. Insec. Soc. 2 (1955) 313–321.

4. Kalshoven, L. G. E. Observations on the inner structure of "Macrotermes gilvus" mounds in Java. Insec. Soc. 3 (1956a) 270–272.

5. Kalshoven, L. G. E. Observations on Macrotermes gilvus Holmgr. in Java. 3. Accommodations of finely cut vegetable matter in the nests. Insec. Soc. 3 (1956b) 455–461.

6. Light, S. F. Present status of our knowledge of the termites of China. Ling. Sci. Jour. 7 (1929) 581–600.

7. Snyder, Thomas E. Our Enemy the Termite. Comstock Publ. Co. Ithaca, New York (1948).

ETTCHELLSIA PHILIPPINENSIS SP. NOV. (DINAPSINÆ, MEGALYRIDÆ, HYMENOPTERA)

By CLARE R. BALTAZAR
Bureau of Plant Industry, Manila

ONE TEXT FIGURE

This is the first record of the occurrence of the family Megalyridæ in the Philippines with one species in the genus *Ettchellsia.*

Genus ETTCHELLSIA Cameron

Ettchellsia CAMERON, Deuts. Ent. Ztschr. (1909) 209. **Type:** *Ettchellsia piliceps* Cameron. Monobasic.

The type specimen from Java is not in the British Museum of Natural History in London nor in the Sarawak Museum, Kuching, where most of Cameron's types are found. The identification here is based on Cameron's description of the genus. *Ettchellsia* is distinct in having the outer orbit of the eye encircled by a carina.

The new species of *Ettchellsia* described here will be the second species in the genus. This genus is rare in collections and the other two specimens that I know extant are those deposited in the U. S. National Museum by C. F. Baker, collected from Sandakan, Borneo.

ETTCHELLSIA PHILIPPINENSIS sp. nov. **fig. 1.**

Female.—Fore wing 4.8 mm long, body including ovipositor 8.0 mm long, ovipositor sheath 3.0 mm long. Head and body polished; head, side of thorax and propodeum, legs, and ovipositor sheath hairy. Antenna 14-segmented, inserted just above clypeus; clypeus with a midapical notch; mandible tridentate; malar groove distinct; antennal scrobe adjacent to clypeus, carinate on outer side; frons slightly convex with some rugosity above antennæ; eye hairy, encircled by a carina near its outer orbit; occipital carina entire and bordering hind margin of head. Mesoscutum polished with a deep median furrow, with a vertical carina on the front face of mesoscutum; scutellum evenly convex; propodeum carinate, with the middle area or areola transversely striate; pleurum with bumps or surface rugged; mesosternal fork present, similar to the metasternal fork in the Evaniidæ; wing venation as in Fig. 1; front leg with tibia 0.8 as long as femur, with one tibial spur, tarsus

as long as the two trochanters and femur united, basitarsus as long as the rest of tarsal segments together, fourth tarsal segment small, the last somewhat enlarged, claws simple; middle leg similar to front leg except that the tibia is subequal in length to femur, mesosternal fork ending at the middle of coxa, hind leg with coxa enlarged and with a longitudinal carina dorsally, with femur much larger than in other legs, tibia longitudinally wrinkled, two tibial spurs present, tarsus 0.9 as long as tibia, basitarsus 0.6 the length of tarsus and thicker than the other segments, tarsal segments 2 to 4 short and ring-like, last segment equal in length to segments 2 to 4 united. Abdomen elongate-oval, polished except for reticulate tergite 7 and basal half of tergite 6; first tergite 0.3 the entire length of abdomen, tergite 2 and 3 together equal in length to first tergite, and also equal to tergites 4 to 7 united; subgenital plate large; ovipositor slender with 14 ridges at apex.

FIG. 1. *Ettchellsia philippinensis* sp. nov. side view.

Black. Front and middle legs yellowish brown except for dark last tarsal segment; hind leg black except for yellowish brown trochanters and reddish brown femur; ovipositor yellowish brown; antenna, except for yellowish scape and ovipositor sheath, dark brown; fore wing clear with a tinge of yellow, margin of distal 0.3 of wing brownish; hind wing clear.

Male.—Unknown.

Type.—♀, Sierra Bullones, Bohol, 1,200 feet, April 26, 1955, C. R. Baltazar (Bureau of Plant Industry, Manila).

A NEW CHALCID FROM THE PHILIPPINES (PERILAMPIDÆ, HYMENOPTERA)

By CLARE R. BALTAZAR
Bureau of Plant Industry, Manila

ONE TEXT FIGURE

The genus *Monacon,* in which the new species described here belongs, has not heretofore been recorded from the Philippines. It is a very unique genus and is easily singled out from the rest of the Philippine chalcids because of the presence of a frontal spine at the middle of the head. As in all Perilampidæ the gaster is small and subtriangular, the fused second and third tergites cover most of the abdomen, and the thorax is broad and short.

MONACON FERRIEREI sp. nov. **Fig. 1.**

Female.—Fore wing 3.5 mm long, body 4.0 mm long. Head reticulate, thorax punctate, abdomen polished; body hairy except for basal half of abdomen. Head twice as wide as long when measured dorsally, anteriorly its width equals 1.2 times the depth of head; frontal scrobe large and deep, mat, hairless, carinate on outer side; frontal spine situated at the middle of head, between antennal fossæ; clypeus flat, its apical margin straight, with a small tuberosity on each basal corner; mandible bidentate, upper tooth half as long as lower tooth; malar space half as long as scape; antenna with one ring joint and 9 funicular joints, each funicular joint short and broad, scape long, inserted at the middle of head and reaching top of head. Thorax as broad as head, coarsely and closely punctate throughout, the interspaces 0.1 the diameter of punctures; pronotum short and transverse; parapsidal groove distinct and extending over the entire length of mesoscutum; scutellum large, as long as pronotum and meso-

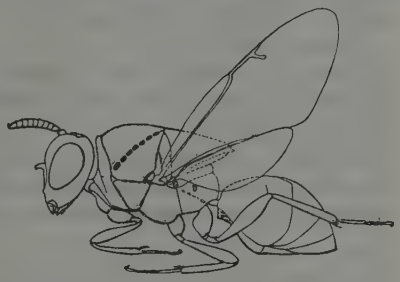

FIG. 1. *Monacon ferrierei* sp. nov. side view.

scutum united, carinate laterally, its apex extending above and beyond tip of propodeum; propodeum short and underneath large scutellum, its posterior face vertical in profile, with a midlongitudinal carina and some transverse carinæ at center, mat and coarsely punctate on outer side; prepectus large and triangular; wings shown in Fig. 1, stigmal vein half as long as marginal vein, postmarginal vein short; fore and middle legs each with one tibial spur; hind leg with coxa small and subglobose, femur as long as tibia, two tibial spurs present with the outer half as long as the inner, tarsus 0.7 as long as tibia, basitarsus as long as the following 4 segments united, claws simple, each with an apically enlarged hair at base. First tergite short and almost hidden, fused tergites 2 and 3 large, covering basal half of abdomen; tergites 4, 5, and 6 together covering other half of abdomen; the rest of tergites retracted; first sternite together with first tergite forming a short petiole; second sternite with a carinate basal flange followed by a depressed area containing 6 longitudinal carinæ; ovipositor not exserted.

Black. Mandible, tegula, wing veins, tibiæ, tarsi and ovipositor yellowish brown; antenna and femora blackish brown.

Male.—Unknown.

Type.—♀, Port Banga, Philippines (probably in Cotabato, Mindanao), December, 1914, Böttcher (Bureau of Plant Industry, Manila).

The species is named after one of the foremost chalcid specialists, Dr. Ch. Ferriere of the Museum of Natural History in Geneva, who gave the specimen to me.

VOLATILITY OF ALCOHOL MOTOR FUELS

By Richard Wiebe,[1] C. B. Kretschmer,[2] and A. P. McCloud[3]
Northern Regional Research Laboratory,[4] Peoria, Illinois

ONE PLATE AND EIGHT TEXT FIGURES

The performance of carburetted engines is largely dependent on correct fuel volatility. Mixture distribution among engine cylinders, crankcase dilution, vapor lock, hot starting and stalling are intimately related to volatility, as well as to engine design. Therefore, different engines may not react similarly toward the same fuel, indicating the almost equal importance of mechanical factors in the evaluation of fuel volatility.

MIXTURE DISTRIBUTION

The fact that the fuel frequently is not distributed evenly among the cylinders of an engine has been known for some time. Donahue and Kent(9) made a rather comprehensive study of a number of gasolines having different boiling characteristics, as well as of pure hydrocarbons, both gaseous and liquid. Their conclusions indicated that engine factors, such as position of the choke valve or any other obstruction in the intake passages, may be more important than a reasonable difference in the volatility of the fuel. As far as the fuel itself is concerned, they stated that, contrary to previous thinking, not only the heaviest components but also the lightest components of the fuel are unevenly distributed. The octane numbers of the fuel in the different cylinders varied materially and in accordance with the octane numbers of the fuel fractions reaching each cylinder. Furthermore, their results indicated that the cylinders receiving more than their share of the light fraction received correspondently less of the heavy fraction and the octane numbers of the fuels in the different cylinders varied therefore in accordance with the respective percentage compositions.

[1] Present address: Office of Critical Tables, National Research Council, Washington, D. C.

[2] Present address: Aerojet Corporation, Azusa, California.

[3] Present address: Continental Oil Company, Ponca City, Oklahoma.

[4] This is a laboratory of the Northern Utilization Research and Development Division, Agricultural Research Service, U. S. D. A.

In connection with our interest in alcohol motor fuels, the Northern Utilization Research Branch studied the effect of alcohol-water injection on mixture distribution. Information on alcohol-water injection itself has been published previously and will not be discussed here.(12, 14, 15)

The experimental work on mixture distribution was carried out in an Oldsmobile 1949 rocket engine coupled to a 100-hp. cradled-type DC dynamometer. The engine is shown in Plate 1, figs. 1 and 2. For sampling the exhaust gas, stainless-steel tubings were inserted in holes drilled in the exhaust pipe, close to each exhaust valve. Exhaust gas samples and alcohol samples could therefore be obtained from each individual cylinder. Thermocouples were placed near each intake valve. By means of a special distributor, the spark timing of each individual cylinder could be varied independently and the octane requirement for trace knock of each cylinder determined separately. With this special distributor, spark timing of any cylinder could be changed from —10 to +25 degrees relative to the other cylinders. To obtain the octane requirement of the individual cylinders, a series of isooctane-*n*-heptane reference fuels ranging from 60 to 95 octane number were used, in 2½ octane number increments. Starting with cylinder No. 1, the spark timing for trace knock was determined for each reference fuel. This was repeated for all cylinders, and data for curves of spark timing for trace knock versus octane numbers were obtained. Similar curve data were determined with use of alcohol-water injection, also.

The fuel-air ratio of the incoming mixture was determined by weighing the fuel and measuring the air in a large flowmeter (Rotameter) with practically zero pressure drop. The fuel-air mixture actually reaching each cylinder was determined by exhaust gas analysis.(8) In order to determine alcohol distribution when injection was used, it was necessary to turn off the ignition and to motor the engine briefly (with the dynamometer) for obtaining samples.

The location of the injector was important. Three different locations were tried and were found to give significantly different results. These variations are shown in Figure 1. Position A was particularly detrimental to distribution. These results confirm Donahue's and Kent's observations that slight structural changes in the intake passage may have an important effect on distribution. In Figures 2, 3, and 4, the octane re-

quirement for trace knock for maximum power at 1,200 r.p.m., with or without alcohol-water injection, is plotted for each of the eight cylinders, using 50:50, 75:25, and 94:6 alcohol-water mixtures at these injection rates. These rates are stated in per cent of volume of the gasoline used or, in other words, equal to the ratio of the volume of alcohol to the volume of gasoline. The upper curves in each of the figures give the

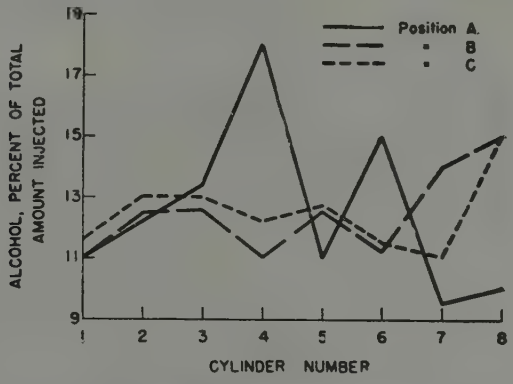

FIG. 1. Effect of location of injector on the distribution of alcohol.

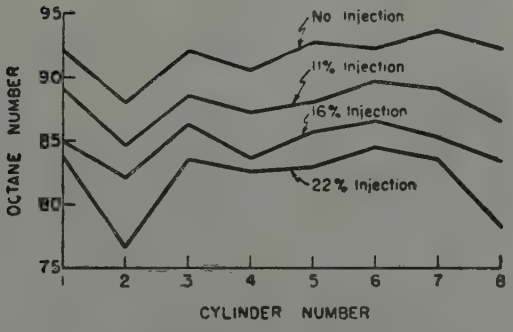

FIG. 2. Lowering of octane number requirement with injection. Distribution pattern when injecting at 50:50 alcohol-water mixture at three injection rates, at 1,200 r.p.m. and maximum power.

octane requirement of each cylinder without use of injection. With injection, the octane requirement is lowered, as indicated by the graphs for 11, 16, and 22 per cent injection, and a

gasoline of lower octane number therefore could be used. For example, the data of Figure 4 show that, without injection, cylinder No. 1 needed a gasoline of 92 octane number while with a 22 per cent injection of 50:50 alcohol-water mixture, this cylinder could be operated with a gasoline of octane number of 83.7.

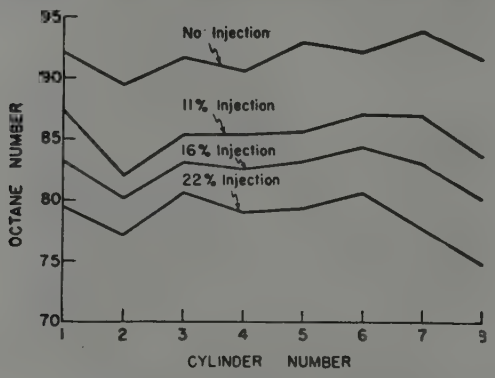

FIG. 3. Lowering of octane number requirement with injection. Distribution pattern when injecting at 75:25 alcohol-water mixture at three injection rates, at 1,200 r.p.m and maximum power.

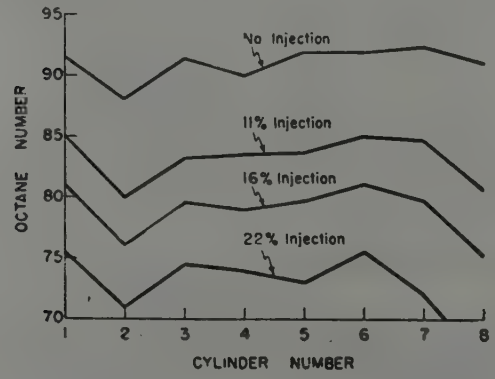

FIG. 4. Lowering of octane requirement with injection. Distribution pattern when injecting a 94:6 alcohol-water mixture at three injection rates, at 1,200 r.p.m. and maximum power.

The results clearly indicate that actually it may not be the whole engine which knocks, and that knock may occur only in one or two cylinders. Injection causes a slight distortion in the fuel distribution. It is particularly noticeable in the end cylinders and is most pronounced with the highest percentage of water in the alcohol mixture. The higher the percentage of alcohol in the mixture, the greater its knock-suppressing effectiveness and, consequently, the greater the lowering of the octane requirement of the engine.

CRANKCASE DILUTION

A recent paper on problems related to gasoline volatility(10) stated that cooperating laboratories agree that crankcase dilution increases with the "90 per cent point" of the fuel used. In other words, the higher the temperature at which 90 per cent of the gasoline vaporizes, the greater the crankcase dilution. Except for this, the data permitted no further conclusions.

In connection with engine wear tests at the Northern Utilization Research Branch,(4) the viscosity of the lubricating oils was determined at intervals during the test runs. The wear tests were performed in the laboratory under simulated road conditions. The engine changed periodically from idling, to road load, to acceleration, to shut down, back to idling, etc. Table 1 gives the ASTM distillation data for the fuels used.

TABLE 1.—*ASTM distillation data for the fuels used.*

Fuels	Temperatures ° C.			
	A [1]	B [1]	C [2]	D [2]
Initial boiling point	51.0	41.0	60.5	48.3
10 per cent	58.8	68.2	87.2	73.8
50 per cent	85.5	116.0	129.3	127.1
90 per cent	118.2	167.1	169.3	173.8
End point	116.6	203.2	197.7	198.8
Octane no. research	68.7	53.1	64.6	67.4
Octane no. motor	66.6	51.1	60.0	62.0

[1] Straight run fuels.

[2] Special fuels with sulfur contents of 0.14 and 0.26 per cent of sulfur, respectively.

Gasolines used in these tests do not represent regular and premium gasolines now sold in the United States; however, the results are still of interest since they bear out the conclusions expressed by Dugan, et al.,(10) as stated above.

Table 2 gives some of the results obtained. Fuel A was outstanding, as would be expected from its low 90 per cent point. Results with fuels B, C, and D clearly indicate the

TABLE 2.—*Different results obtained from fuels A to D.*

Fuel	Time at which sample was taken, in hours	Viscosity in centistokes at 37.7° C.
A	0	78.5
	50	65.4
A + 0.13 per cent S	0	73.2
	50	66.1
A + 25 per cent alcohol + 0.13 per cent S	0	74.2
	50	68.3
B	0	75.3
	50	59.5
B + 3 ml. TEL/gal	0	74.1
	50	44.9
B + 25 per cent alcohol + 3 ml TEL/gal	0	72.4
	50	54.8
C	0	72.3
	50	36.4
C + 25 per cent injection (50:50 alcohol-water mixture)	0	72.6
	50	32.4
D	0	72.5
	50	26.9
D + 25 per cent injection	0	70.3
	50	26.8

effect of high 90 per cent distillation temperature. This is particularly apparent in fuels C and D, in which case, however, the relatively higher 50 per cent points give an indication of a greater proportion of the high boiling constituents. Alcohol appears to have no effect on crankcase dilution.

VAPOR LOCK

Vapor lock is defined as the formation of vapor bubbles within the fuel-handling system of an automobile to such an extent that insufficient fuel can be supplied to the engine for normal operation. Incipient vapor lock causes slowness or hesitation in acceleration when the throttle is opened. Severe vapor lock causes complete stoppage of the engine, which cannot then be restarted until the fuel pump has had time to cool off.

In modern petroleum-refining practices, large amounts of 4- or 5-carbon hydrocarbons are produced which could be most profitably utilized by incorporating them in gasoline. These, however, tend to have relatively high volatility. As more and more of these fractions became available for incorporation into gasoline, the vapor pressure of commercial gasolines increased slowly but steadily during the past 20 years. In some instances, this has caused difficulties with vapor lock.

The vapor pressure of ethyl alcohol is much lower than that of a typical gasoline, yet the addition of up to 25 per cent of ethyl alcohol to gasoline raises the vapor pressure of the resulting blend and increases its tendency to vapor lock. This

is because ethyl alcohol, in common with other lower alcohols, forms low-boiling mixtures (azeotropes) with the hydrocarbons present in gasoline. The addition of alcohol to present-day gasolines would therefore aggravate the tendency toward vapor lock. Difficulties with vapor lock were experienced several years ago in Switzerland, where the use of alcohol blends had to be discontinued during summer to avoid vapor lock.(5) Similar difficulties with alcohol-gasoline blends were also experienced in Cuba.[5]

The distillation characteristics of alcohol blends have been thoroughly investigated in the past. Ribagnac,(13) for instance, published distillation curves for a number of blends of alcohol with gasoline and benzene (benzol). These curves indicated clearly that the resulting alcohol blends had a significantly higher vapor pressure (lower boiling points) than the original hydrocarbon mixtures. As an illustration, Figure 7 shows the ASTM distillation curves of a typical gasoline, straight and as blended with 10 and 25 per cent alcohol. The presence of alcohol produces a characteristic flattening of the curve, which extends here to "70 per cent evaporated," and corresponds to the evaporation of part of the gasoline hydrocarbons as low-boiling mixtures with the alcohol.

In the petroleum industry, the volatility characteristics of gasoline are specified by the ASTM distillation curve, as shown in Figure 5, and by the Reid Vapor Pressure (RVP; ASTM designation: D86–53). The latter is the vapor pressure that would be exerted by a sample of gasoline at 100° F if it were introduced into an evacuated bomb having a volume five times as large as the volume of the sample. The average values of the RVP of gasoline in the United States were 0.58 kg/cm^2 during the summer period of 1954(2) and 0.76 kg/cm^2 during the winter 1954–55.(3)

The Reid vapor pressures of three fuels and their alcohol blends are shown in Figure 6. The significance of the designation "low" and "high" slopes will be given later. Addition of alcohol increases the RVP of the gasolines, and maximum RVP is attained at about 10 per cent alcohol, indicating that at least the lower alcohol blends are more volatile than the base gasolines.

Since the publication of a paper by Aldrich, Barber, and Robinson,(1) we know that the fuel characteristic which directly

[5] Personal communication.

controls the occurrence of vapor lock is neither the distillation curve nor the RVP, but the vapor-liquid (V/L) ratio. This is the ratio of the volume of vapor produced by a sample of

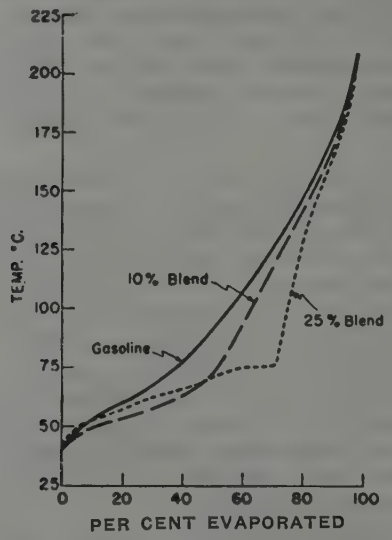

FIG. 5. ASTM distillation curves for gasoline and for 10 and 25 per cent alcohol blends of the same gasoline.

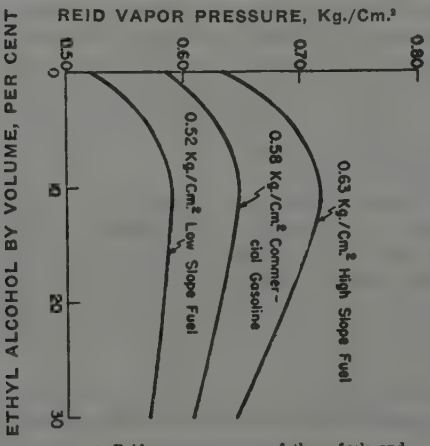

FIG. 6. Reid vapor pressure of three fuels and their alcohol blends.

the fuel, at a given temperature and pressure, to the volume of the portion of the sample remaining unvaporized. Although the V/L ratio is a function of temperature and pressure, it is ordinarily measured only at a pressure of one atmosphere. Each part of the fuel system of a vehicle has a certain critical value of V/L, which is the maximum ratio of vapor to liquid that can be transmitted by that part of the system and still provide enough total flow of fuel to maintain normal engine operation. If the pressure and temperature at any point in the fuel system are such as to cause the fuel being used to have a higher V/L than this critical value, then vapor lock will occur. Ordinarily this occurs on the inlet side of the fuel pump. Critical V/L ratio lies somewhere between 15 and 60.

Figure 7 gives the V/L curves for three fuels, (*a*) a commercial summer gasoline (Fuel D, see Table 3), (*b*) a 10 per cent alcohol blend with the same gasoline, and (*c*) a gasoline having the same RVP as the 10 per cent blend. The blend reaches any given value of V/L at a considerably lower temperature than the unblended gasoline, and the rate of increase of temperature with V/L is much smaller for the blend than the gasoline. The dashed curve in Figure 7 shows the behavior of a gasoline similar in composition to that of the unblended gasoline represented by the upper solid curve, but with a RVP equal to that of the 10 per cent blend. The dashed curve crosses the curve for the blend at a V/L ratio somewhat less than 4, since the RVP is measured at a V/L ratio of 4, but is approximately parallel to the curve for the 0.58 kg/cm^2 gasoline. Any V/L ratio greater than 4 will be attained more by the blend at a lower temperature than by the 0.65 kg/cm^2 gasoline. In other words, the blend will cause vapor lock at a lower temperature more than an unblended gasoline of the same RVP.

The slope of the V/L curve for a fuel is directly related to the slope of the initial portion of the ASTM distillation curve. For practical purposes, the slope of the initial portion of the ASTM distillation curve is defined as $\frac{1}{10}$ of the difference in degrees Fahrenheit between the 5 and 15 "per cent evaporated" points on the distillation curve. Commercial gasolines have slopes of 1.5 to 3.0. A fuel with a low slope in the distillation curve has a small rate of increase of temperature with V/L, as may be seen by comparing the curves for the alcohol blend with those for the straight gasoline in Figures 6 and 7.

TABLE 3.—*Fuel properties and road test results.*

Fuel [3] and per cent ethanol	RVP kg/cm²	Temperature for V/L values, °C				Ambient temperature °C	Degree of vapor lock
		4	10	30	45		
A	0.53	57.2	63.9	71.4	74.4	31.7	None
A + 10	0.63	49.7	52.2	56.9	58.9	28.3	None
A + 15	0.64	50.6	52.8	56.9	58.9	32.2	None
A + 25	0.58	50.6	53.3	57.8	60.0	32.2	None
B	0.53	51.7	60.6	65.0	67.2	35.0	None
B + 10	0.60	50.6	52.8	55.0	56.1	33.3	None
B + 10	0.60	50.6	52.8	55.0	56.1	35.0	Incipient
B + 15	0.59	50.6	52.8	55.6	56.7	33.9	None
B + 15	0.59	50.6	52.8	55.6	56.7	35.6	Incipient
B + 25	0.58	51.7	52.8	55.6	56.9	34.4	None
B + 25	0.58	51.7	52.8	55.6	56.9	36.4	Incipient
C	0.58	55.0	57.8	63.3	67.2	31.1	None
C + 10	0.65	48.9	51.7	55.6	57.2	32.8	None
C + 15	0.64	49.4	51.4	54.4	56.1	33.9	None
C + 25	0.62	49.7	51.7	55.0	56.7	34.2	Incipient
D	0.58	54.2	57.2	63.3	66.7	31.1	None
D + 10	0.65	48.9	50.8	54.4	56.1	31.1	None
D + 15	0.64	49.4	51.1	55.0	57.2	32.2	None
D + 25	0.62	50.3	52.2	56.1	58.3	32.8	None
E	0.54	56.4	59.4	64.4	66.7	37.2	None
E + 10	0.60	50.0	57.5	54.4	55.6	36.7	None
E + 15	0.60	50.3	57.8	54.4	56.1		
E + 25	0.58	51.4	58.3	55.8	57.5	36.1	None
0.35 kg/cm² low slope	0.37	66.7	68.3	69.4	70.0	25.0	None
+ 10	0.44	57.2	57.8	58.9	59.4	26.1	None
+ 15	0.44	57.2	57.8	58.9	59.4	28.3	None
+ 25	0.44	57.2	57.8	58.9	59.4	28.3	None
0.53 kg/cm² low slope	0.52	56.1	57.8	58.9	59.4	31.1	None
0.53 kg/cm² low slope	0.52	56.1	57.8	58.9	59.4	37.8	Incipient
+ 10	0.59	49.4	50.8	51.9	52.2	29.4	None
+ 10	0.59	49.4	50.8	51.9	52.2	33.9	Incipient
+ 15	0.58	49.7	51.1	52.2	52.8	27.2	None
+ 25	0.58	50.0	51.1	52.2	52.8	30.0	None
0.7 kg/cm² low slope	0.70	46.1	47.8	49.1	49.7	25.8	None
0.7 kg/cm² low slope	0.70	46.1	47.8	49.1	49.7	29.2	Pronounced
+ 10	0.77	43.3	43.9	45.0	45.6	26.1	None
+ 10	0.77	43.3	43.9	45.0	45.6	30.0	Pronounced
+ 15	0.76	43.3	43.9	45.0	45.6	26.7	Incipient
+ 15	0.76	43.3	43.9	45.0	45.6	30.0	Pronounced
+ 25	0.76	43.3	43.9	45.0	45.6	28.1	Pronounced
0.84 kg/cm² low slope	0.84	40.6	41.7	43.3	43.9	26.1	Pronounced
+ 10	0.93	38.3	39.2	40.6	41.4	27.2	Pronounced
+ 15	0.91	38.3	38.9	40.6	41.1		
+ 25	0.88	38.9	40.0	41.1	41.4		
0.7 kg/cm² high slope	0.63	50.8	55.0	68.9	69.4	29.4	None
+ 10	0.72	46.1	48.9	54.2	56.7	28.9	None
+ 25	0.67	48.9	51.1	56.1	58.9	28.3	None
0.7 kg/cm² low slope with 25 per cent benzene	0.60	51.7	52.2	53.9	54.4	30.6	None
+ 10	0.68	47.2	48.6	50.0	50.3	28.9	Incipient
+ 15	0.67	48.3	49.2	50.0	50.3	28.9	Incipient
+ 25	0.66	48.3	49.2	50.0	50.6	28.3	None
+ 25	0.66	48.8	49.2	50.0	50.6	28.6	Incipient
0.84 kg/cm² low slope with 25 per cent benzene	0.67	46.1	48.3	50.3	50.8	33.9	Pronounced

[3] Fuels A through E are commercial summer gasolines.

To obtain an adequate criterion for the occurrence of vapor lock with use of alcohol motor fuels on the road, we compared laboratory data with data obtained on the road.(11) Many fuels were rated in accordance with the CRC procedure.(6) A

passenger car was driven at 60 m.p.h. long enough to allow fuel system temperatures to become stabilized. The car was then stopped and allowed to "soak" for 5 minutes with the engine shut off. During this period, fuel system temperatures

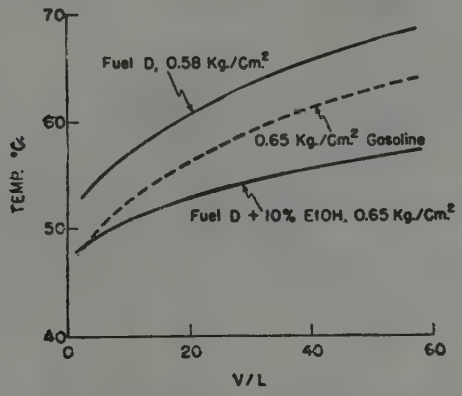

FIG. 7. V/L curves for (*1*) fuel D (regular summer gasoline), (*2*) fuel D with 10 per cent alcohol, and (*3*) gasoline similar to fuel D, but with same RVP as blend.

rose still higher. The engine was then started, and the vehicle was immediately accelerated to 70 m.p.h. as rapidly as possible. Any increase above normal time required for this acceleration was taken as evidence of incipient vapor lock. The car was then stopped and the engine was allowed to idle for 5 minutes. Any irregular operation during this period was also taken as evidence of vapor lock. The ambient air temperature was measured during the "soak" period. All road tests were performed with the same vehicle during the months of June through September. Results are given in Table 3.

Since the critical V/L ratio for the occurrence of vapor lock lies between 15 and 60 for practically all existing vehicles, it was thought that t_{30}, the temperature at which a given fuel has a V/L of 30, would be a suitable criterion for the susceptibility of that fuel to vapor lock. To test this hypothesis on the automobile used in our work, all of our road test results on gasolines and blends were plotted in Figure 8, where t_{30} is shown as ordinate against ambient temperature as abscissa. Symbols indicate the degree of vapor lock encountered. As

shown in the figure, a straight line of unit slope could be drawn, definitely separating conditions for presence or absence of vapor lock. This shows that t_{30} is indeed a suitable criterion for the susceptibility of a fuel to vapor lock in this automobile

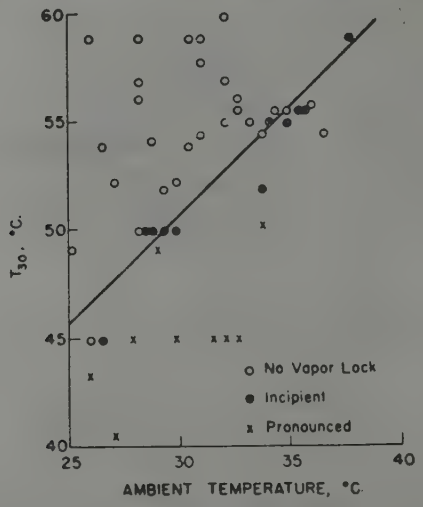

FIG. 8. Vapor lock road test results.

engine. It shows further than any fuel having a value of t_{30}, which is less than 21° above the ambient temperature, will cause vapor lock in this car, a recent stock model of a widely distributed make. It is interesting to note that the lowest value of t_{30} found for any of the commercial summer gasolines examined was 63.3° C. The two gasolines having this value of t_{30} would cause vapor lock in our test vehicle, according to the above analysis, if the ambient temperature rose to 42.8° C. All but one of the alcohol blends of commercial gasolines studied would vapor lock at an ambient temperature of 37.8° C.

Having established the suitability of t_{30} as a criterion for the susceptibility of a fuel to vapor lock, we calculated the RVP of the gasoline that would be required to prepare a 10 per cent alcohol blend of a commercial summer gasoline having suitable resistance to vapor lock. The problem then was to find what the RVP of the gasoline would have to be to prepare

a 10 per cent blend having the same value of t_{30} as the commercial gasoline.

We found that a decrease of 0.25 kg/cm^2 is required to prepare a 10 per cent blend having performance equal to an 0.56 kg/cm^2 summer gasoline, but that an 0.84 kg/cm^2 winter gasoline would require a reduction of only slightly more than 0.07 kg/cm^2.

The results with the 0.7 kg/cm^2 low-slope fuel blended with 25 per cent of benzene indicate that alcohol blends with satisfactory resistance to vapor lock would be prepared by blending a sufficient amount of benzene with the gasoline before adding alcohol. These ternary blends have been used extensively in France with good results. References to this can be found in a recently published bibliography.(16)

The blends prepared from ethyl alcohol containing added methyl alcohol would cause vapor lock at ambient temperatures 1.6 to 2.5° C lower than blends prepared from ethyl alcohol alone.

Brunner(5) has discussed the possibility that, if the alcohol-gasoline blend were prepared from gasoline having a vapor pressure low enough to give the blend satisfactory resistance to vapor lock, the content of light hydrocarbons would be so low that difficulty would be encountered in starting the engine, particularly in winter. However, the effect of adding alcohol is to increase the proportion of hydrocarbons evaporated from the gasoline under any given conditions, and this is true at low temperatures as well as at temperatures at which vapor lock occurs. This effect is sufficient to compensate for the smaller proportion of light hydrocarbons in the blend.

HOT STALLING AND STARTING

Difficulties encountered in engine operation in hot weather with fuels of relatively high volatility have recently been classified under three headings: vapor lock, hot stalling, and hot starting. (10, 7) Vapor lock has already been discussed. Hot stalling was defined as any stalling after a normal stop of a vehicle or refuse of the engine to continue running after a restart. Hot starting was defined as the "excess starting time" of an engine which had been standing for a relatively short time after severe hot-weather operation. No experimental data on these two hot-weather difficulties had been obtained at this

laboratory; however, published data would indicate that in general they, too, are governed by the same variables as vapor lock. It may be true that volatility characteristics other than RVP or V/L may be needed for better correlation between fuel and engine behavior. The same conclusions would apply also to alcohol blends. Just like in vapor lock, blends should have a lower volatility than straight gasoline to show equivalent performance.

REFERENCES

1. Aldrich, E. W., E. M. Barber, and A. E. Robertson. SEA Jour. 53 (1945) 392.
2. Blade, O. C. Bureau of Mines Report of Investigation 5111.
3. Blade, O. C. Bureau of Mines Report of Investigation 5146.
4. Blessin, C. W., C. F. Elder, W. B. Roth, and Richard Wiebe. Exhaust gas composition and engine wear. Unpublished.
5. Brunner, M. Jour. Soc. Ingén. l'Automob. (Paris) 23 (1950) 23.
6. Coordinating Research Council. CRC Handbook. New York, New York (1946) 145.
7. Coordinating Research Council. Passenger Car Hot Weather Fuel Handling Difficulties, Indio, California, 1953. Report, December, 1954.
8. D'Alleva, B. A., and W. G. Lovell. SAE (Trans.) 38 (1936) 90.
9. Donahue, R. W., and R. H. Kent, Jr. SAE Quart. Trans. 4 (1950) 546–557.
10. Dugan, W. P., F. T. Finnigan, J. G. Moxey, and Gilbert Way. A recent look at some problems related to gasoline volatility. Paper presented at the SAE meeting, in Philadelphia, Pennsylvania, November, 1955.
11. Kretschmer, C. G., C. W. Blessin, M. M. Gilbert, W. B. Roth, and Richard Wiebe. Road and Laboratory Tests of Vapor Lock in Alcohol Motor Fuels. Unpublished.
12. Porter, J. C., M. M. Gilbert, H. A. Lykins, and Richard Wiebe. Agr. Engin. 31 (1950) 71–75.
13. Ribagnac, P. Propriétés physico-chimiques de quelques carburants (essence, alcool, benzol) et de leurs mélanges. 11^{me} Congr. Mond. Pétr. Paris, 1937, Sections 3 and 4, Tome 3.
14. Wiebe, Richard. Industr. Agr. Alim. 69 (1952) 203–208.
15. Wiebe, Richard, and John D. Hummell. Agr. Engin. 35 (1954) 319–326.
16. Wiebe, Richard, and Janina Nowakowska. U. S. Dept. Agri. Bibliog. Bull. 10 (1949).

ILLUSTRATIONS

PLATE 1

FIG. 1. Front view of engine.
2. Back view of engine.

TEXT FIGURES

FIG. 1. Effect of location of injector on the distribution of alcohol.
2. Lowering of octane number requirement with injection. Distribution pattern when injecting a 50:50 alcohol-water mixture at three injection rates, at 1,200 r.p.m. and maximum power.
3. Lowering of octane number requirement with injection. Distribution pattern when injecting a 75.25 alcohol-water mixture at three injection rates, at 1,200 r.p.m. and maximum power.
4. Lowering of octane number requirement with injection. Distribution pattern when injecting a 94:6 alcohol-water mixture at three injection rates, at 1,200 r.p.m. and maximum power.
5. ASTM distillation curves for gasoline and for 10 and 25 per cent alcohol blends of the same gasoline.
6. Reid Vapor Pressure of three fuels and their alcohol blends.
7. V/L curves for (*1*) fuel D (regular summer gasoline), (*2*) fuel D with 10 per cent alcohol, and (*3*) gasoline similar to fuel D, but with same RVP as blend.
8. Vapor lock road test results.

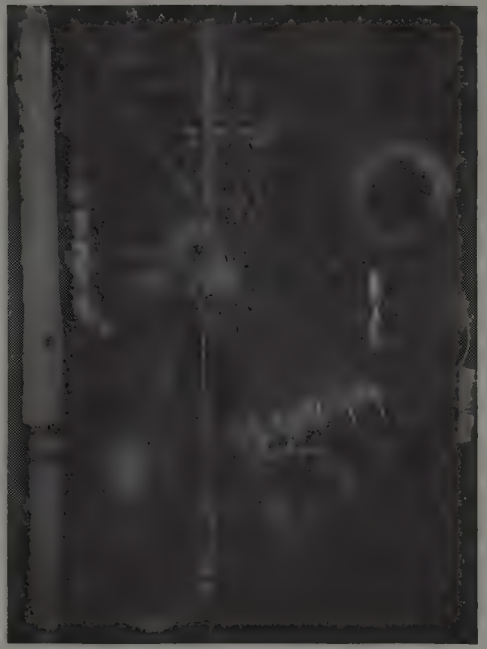

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PLATE 1.

HIGH-COMPRESSION TRACTOR ENGINES WITH ALCOHOL-GASOLINE BLENDS

By M. M. GILBERT,[1] W. B. ROTH, and RICHARD WIEBE[2]
Northern Regional Research Laboratory,[3] Peoria, Illinois

FIVE TEXT FIGURES

Teodoro,(6) Barger,(1) and Wiebe and Nowakowska(8) have made comparative studies of the use of gasoline and alcohol fuels in tractor engines. These tests were made at relatively low compression ratios. Now that higher compression ratios are available for tractors, it was of interest to extend these tests, particularly since alcohol addition may be needed by some higher compression ratio tractor engines. Porter, et al.(5) showed that alcohol-water injection provides a means to bridge the gap between the octane rating of available gasoline and the octane requirement of such engines. The present work deals with recent results obtained at this laboratory with two commercial tractor engines having ranges of compression ratios from 6.8 to 8.5 and from 5.9 to 8.5.

TEST EQUIPMENT AND PROCEDURE

		Minneapolis-Moline tractor[4]	International tractor[4]
Cylinders		4.00	4.00
Bore in inches		4.25	4.00
Stroke in inches		5.00	5.25
Displacement in cubic inches		283.00	283.00
Automatic spark advance	Maximum of 22° reached at 1,200 r.p.m.	Maximum of 25° reached at 1,700 r.p.m.	
Compression ratios	6.8, 8.0, and 8.5:1	5.9, 6.8, and 8.5:1	
Compression ratio changes effected by	cylinder heads	pistons	

In both engines the automatic spark advance was controlled by a flyweight governor without vacuum control. The car-

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[2] Present address: Office of Critical Tables, National Research Council, Washington, D. C.

[3] This is a laboratory of the Northern Utilization Research and Development Division, Agricultural Research Service, U. S. D. A.

[4] Mention in this article of trade names or firms does not constitute an endorsement by the U. S. D. A.

buretors had adjustable needle valves in both idling and high-speed circuits. The speed was controlled by a gear driven, flyweight-type governor.

The engines were in turn coupled to a 100 hp DC cradled-type dynamometer, which could also be used for motoring the engine. Air was measured by means of a flowmeter with practically no pressure drop, and fuel was weighed automatically at intervals.

With each fuel the carburetor high-speed circuit adjustment was obtained with the engine operating at WOT (wide-open throttle). It was noted, from observing the dynamometer torque while varying the adjusting screw, that maximum power remained constant over a wide range of fuel-air ratios. The final setting was made lean. For blends higher than 50 per cent alcohol the diameter of the high-speed jet was increased from 0.74 to 0.105 inches. No change in governor adjustment was made throughout the work.

The manifold mixture heater of the MM tractor has three positions—cool, medium, and hot. During the work under discussion the "medium" setting was used. No manifold adjustments were provided in the International tractor.

The engine was operated at WOT (limited by the governor) throughout the practical speed range of each engine. At each speed the dynamometer torque was recorded during motoring and firing. The time required for burning one pound of fuel was measured electrically. The flow of air into the carburetor was measured in cubic feet per minute by a flowmeter. The pressure drop and the temperature of the air at the carburetor were recorded.

The WOT octane requirement for the MM tractor at 600 to 1,400 r.p.m. and for compression ratios 6.8:1, 8.0:1, and 8.5:1 are shown in Figures 1 to 3. The figures illustrate the fact that knock will be experienced at WOT if the octane number of the fuel is lower than the octane numbers given by the automatic spark advance curve. For illustration note Figure 2. The minimum octane numbers required for WOT at the 8.0:1 compression ratio for knock-free engine operation will be 97 at 800 r.p.m., 98.8 at 1,000 r.p.m., 98.2 at 1,200 r.p.m., and 94.8 at 1,400 r.p.m.

Similar data are shown in Figure 4 for the International tractor at 6.8:1 and 8.5:1 compression ratios and at 1,200 to 1,500 r.p.m. At their respective governed speeds the octane

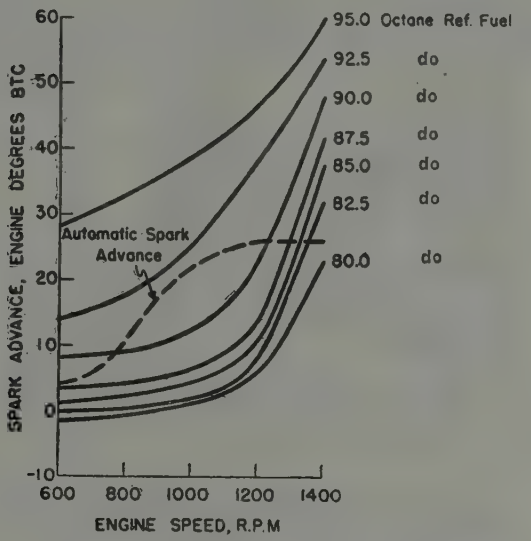

FIG. 1. Octane requirement as a function of speed for Minneapolis-Moline tractor at full-throttle opening and 6.8:1 compression ratio, using primary reference fuels.

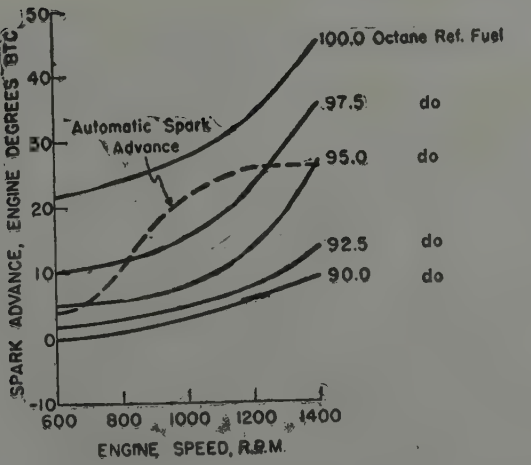

FIG. 2. Octane requirement as a function of speed for Minneapolis-Moline tractor at full-throttle opening and 8.0:1 compression ratio, using primary reference fuels.

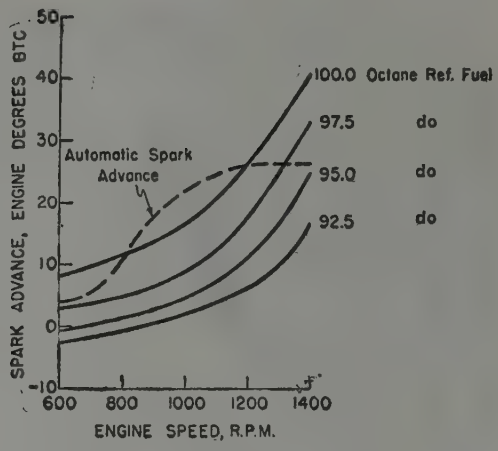

FIG. 3. Octane requirement as a function of speed for Minneapolis-Moline tractor at full-throttle opening and 8.5:1 compression, using primary reference fuels.

requirement of the International tractor is 4 octane numbers lower than that of the MM tractor, presumably because of the International's higher governed speed.

It will be noted that the octane requirement at 8.5:1 exceeds 100 octane numbers in the speed range from about 800 to 1,200 r.p.m. However, it was convenient to use isooctane (=100) as a base fuel for the blends, in spite of the fact that rather heavy knock was experienced at 8.5:1 between 800 and 1,200 r.p.m., so that a comparison could be made with the same hydrocarbon fuel at all three compression ratios. It is well to remember in this connection that a commercial fuel may not rate in a tractor in accordance with its octane number (Research Method ASTM D908–53) but may have a slightly lower rating than isooctane and isooctane–*n*–heptane blends (reference fuels). This applies also to alcohol blended with commercial fuels.

Brake horsepower and specific fuel consumption in lbs./hp hr. for the MM tractor with isooctane, ethanol, and for five of their blends, are given in Table 1. The power output was greater with the addition of alcohol, especially for the higher alcohol content. For instance, at 1,250 r.p.m. this increase amounted to about 4 hp. On the other hand, the specific fuel consumption

also was higher, because alcohol has a lower heat of combustion per pound than isooctane. On the volumetric basis the fuel-consumption figures would be more favorable because of the higher density of alcohol.

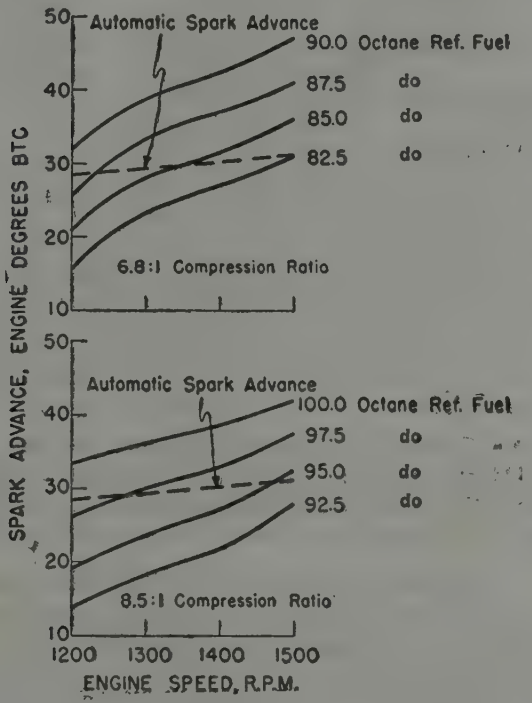

FIG. 4. Octane requirement as a function of speed for International tractor at full-throttle opening at two compression ratios, using primary reference fuels.

The advantages of higher compression ratios are clearly indicated in Table 1. Since 100-octane fuels are not yet sold commercially, the higher thermal efficiency achieved would compensate somewhat for the higher fuel consumption of alcohol blends, if these could be used at higher compression ratios than the available gasolines. A commercial gasoline with octane number of 92 (Research Method ASTM D908–53) would give satisfactory performance in the 6.8:1 tractor, in accordance with Figure 1. As shown in Table 2, without carburetor ad-

TABLE 1.—*Isooctane-ethanol blends at wide open throttle, 27° BTC.*

Fuel	Compression ratio	Brake horsepower corrected (at r.p.m.)					Specific fuel consumption (lbs./hp hr.)				
		1000	1100	1200	1250	1300	1000	1100	1200	1250	1300
Isooctane	6.8	43.1	47.1	50.8	52.4	54.0	0.492	0.488	0.485	0.482	0.480
	8.0	46.4	50.6	54.5	56.4	58.2	0.460	0.451	0.450	0.450	0.450
	8.5	46.9	51.3	55.3	57.2	59.1	0.450	0.445	0.442	0.441	0.442
+ 10 per cent ethanol	6.8	43.2	47.3	51.1	52.8	54.4	0.521	0.520	0.500	0.498	0.495
	8.0	46.6	51.0	55.1	56.9	58.6	0.473	0.469	0.467	0.466	0.467
	8.5	47.1	51.6	55.7	57.6	59.5	0.460	0.458	0.455	0.453	0.455
+ 25 per cent ethanol	6.8	43.5	47.7	51.5	53.2	54.7	0.538	0.530	0.525	0.524	0.524
	8.0	46.8	51.3	55.5	57.5	59.2	0.500	0.590	0.488	0.589	0.589
	8.5	47.7	52.2	56.3	58.3	60.2	0.495	0.488	0.485	0.483	0.485
+ 35 per cent ethanol	6.8	43.8	48.2	52.0	53.7	55.2	0.552	0.547	0.542	0.540	0.540
	8.0	47.9	52.2	56.3	58.1	59.7	0.535	0.520	0.515	0.512	0.512
	8.5	48.3	52.6	56.7	58.6	60.3	0.517	0.509	0.503	0.502	0.500
+ 50 per cent ethanol	6.8	44.2	48.5	52.4	54.1	55.5	0.600	0.590	0.585	0.583	0.582
	8.0	48.1	52.6	56.7	58.5	60.2	0.560	0.552	0.550	0.550	0.550
	8.5	48.7	53.2	57.2	59.2	61.1	0.550	0.543	0.538	0.536	0.535
+ 65 per cent ethanol	6.8	44.8	49.0	52.8	54.5	56.2	0.637	0.625	0.619	0.615	0.613
	8.0	48.4	53.2	57.4	59.3	61.0	0.585	0.575	0.572	0.571	0.570
	8.5	49.3	53.8	58.0	60.0	61.9	0.578	0.567	0.562	0.561	0.560
100 per cent ethanol	6.8	46.6	50.4	54.4	56.4	58.2	0.750	0.750	0.750	0.750	0.750
	8.0	48.9	53.6	57.7	59.6	61.2	0.710	0.704	0.700	0.696	0.695
	8.5	50.2	54.8	59.0	61.0	62.8	0.682	0.676	0.670	0.678	0.667

justment (increase in the size of the jet) the leanness of the alcohol blends causes a reduction of maximum power; but on the other hand, the specific fuel consumption remains the same whether the engine is operated with or without alcohol.

TABLE 2.—*Commercial premium gasoline ethanol blends compression ratio 6.8.*

Corrected brake horsepower (r. p. m.)

Fuel	600	800	1000	1200	1250	1300	1400
Premium	22.0	32.6	43.0	50.0	51.7	53.1	56.2
Premium + 10 per cent	22.9	33.2	43.2	50.0	51.6	52.8	56.2
Premium + 15 per cent	22.6	32.8	42.7	49.3	50.6	52.0	55.1
Premium + 25 per cent	23.5	32.8	41.8	48.2	49.4	50.6	53.8

Specific fuel consumption (lbs./hp. hr.)

Fuel	600	800	1000	1200	1250	1300	1400
Premium	0.698	0.537	0.485	0.475	0.475	0.482	0.512
Premium + 10 per cent	0.655	0.530	0.480	0.473	0.473	0.478	0.502
Premium + 15 per cent	0.655	0.527	0.480	0.470	0.470	0.472	0.483
Premium + 25 per cent	0.716	0.560	0.492	0.480	0.481	0.488	0.516

Straight commercial premium gasolines could not be used at any compression ratios higher than 6.8:1, and Table 3 shows the limitations of the use of blends with commercial fuels at the 8.5.1 ratio. In the case of the first three blends it was necessary to retard the spark from 26° advance, the setting for

TABLE 3.—*Commercial premium gasoline ethanol blends compression ratio 8.5.*

Corrected brake horsepower (r. p. m.)

Fuel	Sp. adv.	600	800	1000	1200	1250	1300	1400
Per cent	° *BTC**							
Com. Prem. + 25	17.0	20.7	34.0	46.0	55.2	57.2	58.5	60.8
Com. Prem. + 35	21.5	23.0	36.0	47.9	57.0	58.8	60.3	62.9
Com. Prem. + 50 **	23.0	21.4	33.9	48.2	57.2	59.0	60.6	64.0
Com. Prem. + 65	26.0	24.0	36.0	49.0	58.2	60.0	61.8	64.7
100 per cent ethanol	26.0	25.2	38.9	49.7	59.0	60.9	62.4	65.0

Specific fuel consumption (lbs./hp. hr.)

Fuel	Sp. adv.	600	800	1000	1200	1250	1300	1400
Per cent	° *BTC**							
Com. Prem. + 25	17.0	0.798	0.630	0.523	0.497	0.494	0.498	0.510
Com. Prem. + 35	21.5	0.835	0.656	0.539	0.508	0.505	0.510	0.520
Com. Prem. + 50 **	23.0	1.070	0.790	0.633	0.615	0.618	0.620	0.633
Com. Prem. + 65	26.0	1.088	0.850	0.730	0.678	0.675	0.676	0.690
100 per cent ethanol	26.0	1.000	0.820	0.719	0.695	0.698	0.700	0.712

* Before Top Center (BTC).

** To operate on blends containing 50 per cent or more of ethanol it was necessary to enlarge the carburetor high speed jet from 0.074 inches in diameter.

maximum power. The brake horsepower at 1,250 and WOT of two tractors, one operated with gasoline at 6.8:1 and the other at 8.5:1 with a 50-per cent alcohol blend, is 51.7 and 59.0, while the specific fuel consumption is 0.475 and 0.618, respectively. This would mean an increase of about 12.6 per cent in hp and 30 per cent in fuel consumption. Farmers operating high compression tractors with alcohol-water injection(7) valued the increase in power more highly than they did the greater economy of operation.

In general, the two tractors performed similarly at the corresponding compression ratios. It is of interest to note not only the change in octane number requirement but also the power loss occasioned by retarding the spark. These data are given in Table 4. Retarding the spark by more than a few degrees, however, resulted in unsteady operation; therefore, it would not be a practical means for reducing the octane requirement of these engines. If engines could tolerate retarding the

TABLE 4.—*Octane requirement at 1,450 r.p.m., full throttle opening, for international tractor.*

	Carbon hours *				
	1.2	7.2	10.0	35.5	44.4
Degrees					
Maximum power-spark advance 31.5**	94.5	95.0	96.0	95.5	96.5
1 per cent power loss spark advance 25.0	92.5	95.0	93.0	93.5	95.0
2 per cent power loss-spark advance 21.0	91.5	90.0	90.0	92.5	93.5
5 per cent power loss-spark advance 17.0	90.5	93.5	92.5	92.0	92.0
10 per cent power loss-spark advance 12.0	87.0			90.0	90.0

* The time of operation of an engine after carbon removal is termed "carbon hours."
** All spark timing values are engine degrees, before top center (BTC).

spark timing, considerable octane savings could be accomplished.(4)

Table 4 shows the effect of deposit accumulation on octane requirement with carbon hours. Carbon hours are defined as

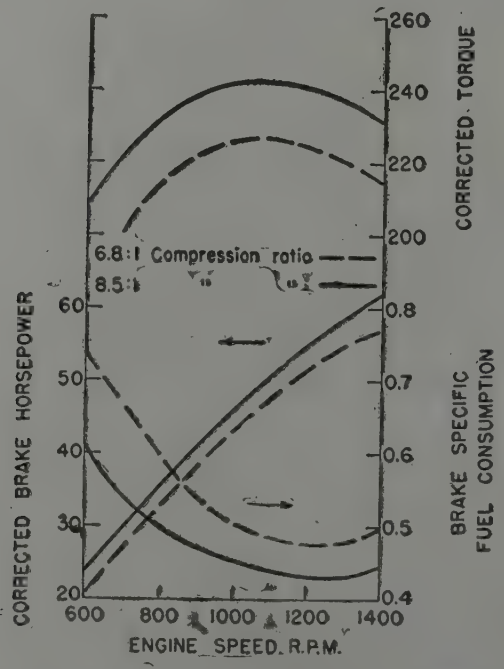

FIG. 5. Torque, brake horsepower and specific fuel consumption for Minneapolis-Moline tractor at full-throttle as a function of RPM.

the time of operation of an engine after carbon removal. This has been investigated a great deal and appears to be caused principally by the thermal insulating properties of the deposit layer.(2)

Figure 5 shows torque, brake horsepower, and specific fuel consumption of the MM tractor at 6.8 and 8.5 compression ratios, at WOT as a function of r.p.m.

Table 5 shows a comparison of the theoretical with the actual thermal efficiency, as a function of the compression ratio. The theoretical efficiency Σ is calculated for $\Sigma = 1\text{-}r^{1-k}$ where r is the compression ratio and k the ratio of the specific heats Cp/Cv. A value of 1.246 instead of 1.4 (the value for perfect gases) was suggested by Lichty,(3) which would conform more closely to the actual value encountered. The reduction in specific fuel consumption would be a direct measure of the practical increase in thermal efficiency with changing compression ratio. The higher figures found in practice are simply an indication of an improvement in the combustion efficiency with higher compression ratios. At the higher compression, increases in thermal efficiency are smaller, but on the other hand, fuels are more expensive and any small increase is important.

TABLE 5.—*A comparison of the theoretical with the actual thermal efficiency, as a function of the compression ratio.*

Compression ratio	Theoretical efficiency		Specific fuel consumption	
	Per cent	Per cent increase	lbs./hp hr.	Per cent decrease
6.8	37.6	----------	0.475	----------
8.0	40.1	6.65	0.435	8.43
8.5	41.0	9.03	0.430	9.47

Alcohol blends may be used in high compression engines which have compression ratios too high for presently available commercial gasolines. The higher possible power output might compensate for the higher fuel consumption in farm operations where the greater load capacity is often an important factor in saving time during planting and harvest operations.

Without carburetor adjustment, the addition of 25 per cent alcohol will cause no increases in specific fuel consumption, and only a slight loss in power.

REFERENCES

1. Barger, E. L. Agri. Eng. (1941) 65–78.

2. Dumont, L. F. SAE Quart. Trans. (1951) 565.

3. Lichty, L. C. Internal Combustion Engines. McGraw-Hill, New York, New York (1951).

4. Mueller, H. T., and R. E. Gish. Paper presented at SAE Tractor Mtg. (September 1954).

5. Poeter, J. C., M. M. Gilbert, H. A. Lykins, and Richard Wiebe. Agri. Eng. **31** (1950) 71–75.

6. Teodoro, A. L. Univ. Philip. Natur. Appl. Sci. Bull. **1** (1931) 187–221.

7. Wiebe, Richard, and John D. Hummell. Agri. Eng. **35** (1954) 319–326.

8. Wiebe, Richard, and Janina Nowakowska. U. S. Dept. Agri. Bibliog. Bull. **10** (1949).

COMPARATIVE STUDY OF SIX LOCAL AND ONE FOREIGN STRAINS OF YEAST IN THE PRODUCTION OF ETHYL ALCOHOL FROM BLACKSTRAP MOLASSES

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Ethyl alcohol is used not only in medicine, in the manufacture of liquors, wines and other alcoholic beverages, and in the perfumery business, but also in the motor-fuel industry. Such multiple uses of alcohol point to its great economic importance and to the need for further research on its production or manufacture.

Statistics show that the Philippines is importing enormous quantities of alcohol from the United States, Great Britain, Canada, West Germany, among others, in the form of motor fuel, denatured alcohol or compound alcohol. Her annual importation based upon a four-year period (1955–1958) amounted to 3,094,430 kilos valued at 2,447,347.00 pesos and the local production was 6,633,608 kilos valued at 2,027,630.00 [1] pesos.

The purpose of this investigation is to determine which of the yeasts in the collection of the National Institute of Science and Technology is good for the production of alcohol from local raw materials. Molasses, for example, is cheap and abundant in the country, and this source of carbohydrates may in turn be utilized in selecting the best strain of local yeast. The selected strains may later be used in the production of ethyl alcohol, from sweet potatoes, cassava and other tubers, which are sometimes thrown away as waste. The successful conversion of the starchy materials into ethyl alcohol for use in medicine and in the motor-fuel industry will always be welcomed as an event of far-reaching significance.

EXPERIMENTAL PROCEDURE

The six selected strains of local yeasts which were previously studied by Hipolito, et al.(4) for thiamin and protein content,

[1] Figures obtained from the Bureau of the Census and Statistics, Manila.

and an imported alcohol yeast (ATCC 4132) obtained through the courtesy of Mr. Hermenegildo R. Rosales, fabrication superintendent of Central Azucarera de Don Pedro, Nasugbu, Batangas, were used in the investigation. Before using them in experiments on alcohol production, they were first invigorated by cultivation in sterile pineapple juice [2] medium [3] and then reisolated in pure culture on Sabouraud's agar. The energizing effect of the treatment was determined by comparing the ethyl alcohol produced by the yeasts so treated in molasses media of 20 and 25 per cent concentrations of total sugar with that produced by similar strains from stock cultures on Sabouraud's agar.

Culturing of the yeast in molasses.—Molasses [4] was used as the nutrient medium in screening for the alcohol-producing power of each strain of yeast as it was easier to prepare and more economical to use than other sources of sugar.

The molasses medium was prepared in dilutions of 5, 10, 15, 20, 25, and 30 per cent total sugar. For each dilution, one and one-half liters was prepared and acidified with a few drops of concentrated sulphuric acid. Four flasks containing 350 cc of each dilution were prepared. Each flask was plugged auto-

[2] Food composition of pineapple juice (from unpublished data, Food and Nutrition Research Center):

Carbohydrates	15.4	g. per 100 grams
Calcium	7.5	mg. per 100 grams
Phosphorus	2.8	mg. per 100 grams
Iron	traces	
Thiamin	0.06	mg. per 100 grams
Riboflavin	0.016	mg. per 100 grams
Niacin	0.19	mg. per 100 grams
Ascorbic acid	4.5	mg. per 100 grams

[3] Composition of pineapple juice medium:

Pineapple juice	100.00	cc.
Ammonium phosphate	0.429	g.
pH	4.5	

[4] Chemical composition of molasses:

Moisture	19.12
Fat	
Protein	2.12
Ash	8.37
Total sugar	61.63
Sucrose	35.22
Reducing sugar	26.41

clave for 30 minutes at 15 pounds pressure and allowed to cool to room temperature. One and four-tenths grams of monobasic ammonium phosphate was added to every 350 cc hydrolyzed molasses. The different batches were then adjusted to pH 4.5. Each flask was inoculated with 4 cc of yeast suspension prepared by mixing yeast cells from six 2-day-old bottle cultures with 100 cc of sterile distilled water.

Selecting the superior yeast strains for alcohol production.— After 48 hours of fermentation at room temperature, 50 cc of fermented molasses medium was taken daily until the seventh day, diluted with 150 cc of distilled water, neutralized with sodium hydroxide solution and then distilled. The alcohol produced was detected and identified by the iodoform process described by Leach and Winton(5) and was determined quantitatively, following the procedure adopted by the Association of Official Agricultural Chemists.(2) Promising strains were selected on the basis of strength of alcohol obtained after 48 hours.

Further study on the efficiency of local strains of yeasts in the production of ethyl alcohol was made by culturing the selected ones simultaneously with the imported strain (ATCC 4132) in molasses medium with 25 per cent total sugar at various pH's (Table 3). The two strains of *Candida* which were found to be poor yielders of ethyl alcohol in the experiment conducted ahead were excluded from this and from succeeding experiments.

RESULTS AND DISCUSSION

Yeasts which have shown a decline in potency for alcohol production as a result of continuous cultivation on Sabouraud's agar can be reactivated by passing them in culture in pineapple juice medium (Table 1). Yeasts precultured in this medium gave higher yields of ethyl alcohol in molasses media containing 20 and 25 per cent total sugar than similar strains not passed in culture in it. An exception is Y–6 (*Candida tropicalis*) which, not being conspicuously tolerant of high concentrations of sugar, as shown in Table 2, did not produce any ethyl alcohol at all after two days of incubation at room temperature. The stimulatory effect of pineapple juice was more pronounced on Y–2 (*S. cerevisiae*) and (ATCC 4132) than on the other yeast strains (Table 1).

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The stimulative influence of pineapple juice on the growth of yeasts and consequent higher efficiency for ethyl alcohol production may be attributed to its nutritional value as indicated by its food composition.[5] The authors believe that it contains s substance similar or closely related to "bios" described by Wildiers,(12) and to "yeast nutrilites" studied by Miller.(7) Both "bios" and "yeast nutrilites" were described as organic substances of complex nature and unknown composition which stimulate the growth of yeasts, bacteria and many other microorganisms.

Since the publication of Wildiers' controversial "bios" there have been accomplished a considerable number of researches concerning growth substances for the proliferation of yeasts and identities of their active components. Prominent among these were the work of Eascott(3) and of Lochhead and Landerkin.(6) It was Williams, Eakin and Snell(14) who showed the relationship of inositol, biotin, pantothenic acid, thiamin and pyridoxin to the growth of strains of *S. cerevisiæ;* confirmed Miller's work on the complementary effect of "bios" fractions; and concluded that the stimulatory effect of "bios" was due principally to a mixture of vitamins.

Pineapple juice is positive in vitamins A and C and has appreciable amounts of thiamin, niacin and riboflavin. Thiamin (Vitamin B_1) was observed by Williams and Bradway(13) to stimulate the growth of certain yeasts, and by Schultz,(10) to have a strongly marked effect on yeast fermentation. The role of the other vitamins of pineapple juice in stimulating yeast fermentation is not known, but it is believed that they are not entirely without any contribution at all.

The two species of *Candida* yeasts (Table 1) are unquestionably poor yielders of ethyl alcohol. They were incapable of producing signs of fermentation in less than ten hours in a medium containing even a low sugar concentration. With the other yeast strains shown in Table 1 signs of alcoholic fermentation, characterized by formation of tiny bubbles of carbon dioxide, were noticed as early as four to five hours after inoculating them into the fermentable medium. Preculturing of *C. guillermondii* in pineapple juice medium had decidedly stimulated it to produce more alcohol in molasses media containing 20 and 25 per cent total sugar despite its low toleration of high concentration of sugar.

[5] See footnote 2 on page 250.

TABLE 1.—*Stimulatory effect of pineapple juice medium on alcohol production by six local and one foreign strains of yeasts in molasses media.*

Yeast strain	Alcohol produced after two days of incubation at room temperature (28 to 32°C) in molasses medium with 20 per cent total sugar.			Alcohol produced after two days of incubation at room temperature (28 to 32°C) in molasses medium with 25 per cent total sugar.		
	With yeast kept viable by continuous culturing on Sabouraud's agar	With yeast precultured in pineapple juice medium	Increase due to the invigorating effect of pineapple juice	With yeast kept viable by continuous culturing on Sabouraud's agar	With yeast precultured in pineapple juice medium	Increase due to the invigorating effect of pineapple juice
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Y-1 (*Saccharomyces* sp.)	7.10	8.00	0.90	6.52	7.62	1.10
Y-2 (*Saccharomyces cerevisiae*)	7.57	9.04	1.47	8.63	10.00	1.37
Y-3 (*Saccharomyces* sp.)	6.47	7.32	0.85	6.42	7.48	1.06
Y-4 (*Saccharomyces* sp.)	5.62	6.34	0.72	5.28	6.10	0.82
Y-5 (*Candida guillermondii*)	1.80	3.00	1.20	0.80	1.60	0.80
Y-6 (*Candida tropicalis*)	0.00	0.00	0.00	0.00	0.00	0.00
ATCC 4132	8.00	9.24	1.24	9.14	10.38	1.24

The seven strains of yeasts showed a wide range of tolerance in total sugar of the molasses medium (Table 2). The optimum concentration for the strains belonging to genus *Saccharomyces* which includes the yeast ATCC, was 25 per cent and the period

TABLE 2.—*Effect of diversifying the periods of incubation on ethyl alcohol production in molasses media of different concentrations of total sugar.*

Yeast strain	Total sugars of molasses medium	Alcohol produced in different periods of fermentation					
		2 days	3 days	4 days	5 days	6 days	7 days
	Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Y-1 *Saccharomyces* sp.	5	2.20	2.00	1.76			
	10	4.50	4.42	4.20	4.10	4.02	3.90
	15	6.88	7.00	6.88	6.72	6.54	3.92
	20	8.00	9.02	9.12	8.72	8.42	7.96
	25	7.62	10.82	10.92	10.44	10.26	9.84
	30	6.12	8.14	8.44	8.98	7.64	7.22
Y-2 *Saccharomyces* sp.	5	2.20	2.12	1.72			
	10	4.54	4.44	4.30	4.28	4.08	4.00
	15	7.00	7.00	6.90	6.80	6.72	6.60
	20	9.04	9.50	9.30	8.86	8.72	8.44
	25	10.00	11.48	11.78	11.40	11.16	11.84
	30	6.22	8.32	8.71	9.24	8.80	8.47
Y-3 *Saccharomyces* sp.	5	2.00	2.00	1.70			
	10	4.35	4.45	4.28	4.16	4.00	3.90
	15	6.92	6.96	8.36	6.52	6.52	6.42
	20	7.32	8.56	8.84	8.34	8.02	7.81
	25	7.48	10.22	10.30	9.82	9.44	8.82
	30	5.84	7.56	7.62	8.02	7.76	6.22
Y-4 *Saccharomyces* sp.	5	2.00	1.92	1.66			
	10	4.32	4.28	4.15	4.06	3.84	3.54
	15	6.66	6.90	6.84	6.42	6.40	6.02
	20	6.34	7.32	8.58	7.62	7.24	7.08
	25	6.10	9.82	9.60	9.42	9.02	8.61
	30	5.62	7.22	7.31	6.84	6.32	5.92
Y-5 *Candida guillermondii*	5	1.92	2.00	2.00	1.84		
	10	3.30	3.60	4.00	4.52	4.20	3.86
	15	3.30	3.40	4.00	4.40	4.50	4.62
	20	3.00	3.60	4.08	4.46	4.52	4.60
	25	1.60	2.50	2.70	2.84	3.32	3.64
	30	0.00	0.00	0.84	0.96	1.24	1.20
Y-6 *Candida tropicalis*	5	2.14	0.96	0.76	0.66		
	10	0.26	0.46	2.18	2.28	2.38	2.32
	15	0.66	0.92	1.12	2.16	2.06	2.00
	20	0.00	0.00	1.10	2.02	2.00	2.00
	25	0.00	0.00	0.32	0.65	1.72	1.56
	30	0.00	0.00	0.00	0.34	0.56	0.66
ATCC 4132	5	2.20	2.14	1.80			
	10	4.50	4.45	4.45	4.40	4.14	4.08
	15	7.00	6.94	6.90	6.84	6.80	6.64
	20	9.24	9.54	9.30	8.94	8.82	8.60
	25	10.38	11.72	12.08	11.84	11.70	11.36
	30	6.42	8.42	8.86	9.42	9.04	8.72

of fermentation necessary for the production of maximum amount of ethyl alcohol was usually four days. The optimum limit of toleration of total sugar of the two species of *Candida* yeasts (Table 2) was 10 per cent and the maximum production of ethyl alcohol at this concentration was attained after five days in the case of *C. guillermondii* and six days in the case of

C. tropicalis. Owing to their poor performance as alcohol producers they were excluded in subsequent experiments.

The selected strains of yeast have practically the same pH requirements (Table 3). The optimum for the strain of yeast belonging to genus *Saccharomyces* is pH 4.5 and may stretch

TABLE 3.—*Influence of pH on ethyl alcohol production by the selected strains of yeast in molasses medium of 25 per cent concentration of total sugar.*

Yeast strain	pH of molasses medium	Alcohol produced in different periods of fermentation					
		2 days	3 days	4 days	5 days	6 days	7 days
		Per cent	*Per cent*	*Per cent*	*Per cent*	*Per cent*	*Per cent*
Y-1 *Saccharomyces* sp.	3.0	0.07	0.11	0.26	0.32	-------	-------
	3.5	2.26	5.58	6.24	6.00	5.82	5.60
	4.0	6.54	9.12	9.48	9.08	8.71	8.78
	4.5	7.62	10.82	10.92	10.44	10.26	9.84
	5.0	7.42	10.42	10.54	10.22	9.96	9.72
	5.5	6.42	9.40	9.66	9.42	9.28	8.86
	6.0	5.88	8.36	8.62	8.32	7.96	7.84
Y-2 *Saccharomyces cerevisiae*	3.0	0.13	0.46	0.53	0.68	-------	-------
	3.5	5.02	7.80	8.00	7.62	7.54	7.40
	4.0	7.32	9.38	9.64	9.32	8.84	8.70
	4.5	10.00	11.48	11.78	11.40	11.16	10.84
	5.0	8.12	10.20	11.28	11.00	10.82	10.42
	5.5	7.52	10.12	10.22	9.68	9.46	9.12
	6.0	6.02	8.67	8.78	8.48	8.22	8.14
Y-3 *Saccharomyces* sp.	3.0	0.00	0.11	0.16	0.32	0.00	-------
	3.5	1.79	3.92	5.98	5.80	5.60	5.44
	4.0	5.62	8.64	8.80	8.56	8.32	8.04
	4.5	7.48	10.22	10.30	9.82	9.44	8.82
	5.0	7.02	9.22	9.46	9.02	8.84	8.41
	5.5	6.02	8.86	8.72	8.56	8.38	8.21
	6.0	5.46	7.93	8.36	8.02	7.64	7.28
Y-4 *Saccharomyces* sp.	3.0	0.00	0.00	0.07	0.21	-------	-------
	3.5	0.00	0.00	1.32	1.52	1.30	-------
	4.0	5.02	7.64	8.72	7.60	7.30	-------
	4.5	6.10	9.32	9.60	9.42	9.02	8.61
	5.0	5.92	8.98	9.04	8.74	8.48	8.06
	5.5	5.61	8.62	8.47	8.22	8.04	7.42
	6.0	5.02	7.67	7.91	7.45	7.31	6.88
ATCC 4132	3.0	0.26	0.66	0.74	0.72	-------	-------
	3.5	5.58	8.00	8.24	7.90	7.72	7.50
	4.0	7.68	9.52	9.72	9.51	8.92	8.76
	4.5	10.38	11.72	12.08	11.84	11.70	11.36
	5.0	8.18	11.48	12.02	11.74	11.62	11.24
	5.5	7.66	10.72	10.78	10.42	10.24	8.86
	6.0	7.02	9.20	9.44	9.11	8.64	8.32

to a pH slightly higher than this. It is about the optimum pH for the alcohol-producing yeast, *Saccharomyces cerevisiæ* of the brewing industry and *Saccharomyces cerevisiæ* var. *ellipsoideus* of the alcohol-wine industry. It falls also within the optimum range of some strains of industrial yeasts described by Prescott and Dunn(8) and Underkofler and Hickey.(11)

On the fourth day of fermentation the imported strain of *Saccharomyces* (ATCC 4132) made a slight ascent above the

local strain of *Saccharomyces cerevisiæ* in ethyl alcohol production (Table 3). The former produced 12.08 per cent ethyl alcohol, which was only 0.3 per cent higher than that produced by the latter. The ethyl alcohol produced by each of the other three strains of local *Saccharomyces*, namely Y–1, Y–3 and Y–4, was smaller by 1.16 per cent, 1.78 per cent and 2.48 per cent, respectively, than the imported strain (ATCC 4132).

After the fourth day of fermentation the output percentage of ethyl alcohol began to decrease (Table 3 and 4). The residual sugars determined and calculated as dextrose in accordance

TABLE 4.—*Sugar-assimilating power and alcohol-producing, efficiency of selected strains of yeasts in four days of fermentation at pH 4.5 of the molasses medium containing 25 per cent total reducing sugar.*

Yeast strain	Residual sugars	Alcohol produced	Fermentation efficiency
	Per cent	*Per cent*	*Per cent*
Y–1 *Saccharomyces* sp.	2.69	10.92	85.51
Y–2 *Saccharomyces cerevisiæ*	1.39	11.78	92.17
Y–3 *Saccharomyces* sp.	3.78	10.30	80.65
Y–4 *Saccharomyces* sp.	5.25	9.60	75.17
ATCC 4132	1.11	12.08	94.52

with the method of the Association of Official Agricultural Chemists(2) ranged from 1.11 per cent to 5.25 per cent (Table 4). The residual sugar of the fermenting mash in which the local *Saccharomyces cerevisiæ* was cultured was 0.28 per cent higher than that of the fermenting medium in which the imported strain (ATCC 4132) was cultivated.

The local strain of *S. cerevisiæ* isolated from ripe papaya fruit can simulate the imported strain (ATCC 4132) in the production of ethyl alcohol. The former produced 11.78 per cent alcohol after four days of fermentation to come close to 12.08 per cent produced by the latter (Table 4). The figures are close to the 12 to 14 per cent ethyl alcohol obtained by Rao and his associates(9) from the molasses mash of high concentration and are within the 10 to 13.5 per cent obtained by Arroyo(1) with his own fermentation technique.

A computation made on the basis of theoretical yield of 12.77 grams of ethyl alcohol per 100 grams of molasses medium containing 25 per cent total reducing sugar gave the fermentation efficiency of the selected strains of yeasts indicated in Table 4. The fermentation efficiency figures reveal that they are roughly inversely proportional to residual sugar present

in the fermented molasses mash and that of all the yeast cultures present in the stock collection of the National Institute of Science and Technology only two strains, one local (*S. cerevisiæ*) and the other foreign (ATCC 4132), are highly efficient and recommendable for use in the manufacture of ethyl alcohol locally from molasses.

SUMMARY

1. Seven strains of yeasts, six local and one foreign, from the old stock collection of the National Institute of Science and Technology, Manila were invigorated by passing them in culture in pineapple juice medium. Positive response to invigoration was obtained with yeasts capable of producing much alcohol and showing remarkable tolerance of high concentrations of sugar.

2. For conspicuous alcohol-producing yeasts the optimum limits of toleration of total reducing sugar in the molasses medium was found to be 25 per cent and the period of fermentation required to attain maximum production of ethyl alcohol was four days.

3. The pH optimum of 4.5 for the yeasts dealt with in this investigation is more or less the same as that of the industrial yeasts of the alcohol-wine and beer industries.

4. The local strain Y–2 (*S. cerevisiæ*) isolated from rotting papaya fruit and the foreign strain (ATCC 4132), which were found to be as highly efficient as the wine and beer yeasts in the production of ethyl alcohol from molasses media, are the only yeasts recommendable for use in fermentation industries wherein the desired end-product is principally ethyl alcohol.

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REFERENCES

1. Arroyo, Rafael. The Arroyo fermentation process for alcohol and light rum from blackstrap molasses. Sugar Journ. 11 (1949) 5–12.

2. Association of Official Agricultural Chemists. Official Methods of Analysis of the Association of Official Agricultural Chemists. Washington, D.C. (1955) xvi + 1008 pp.

3. EASCOTT, EDNA V. Wildiers' Bios. The isolation and identification of "Bios 1." Journ. Phys. Chemi. 32 (1928) 1094–1111.

4. HIPOLITO, DOLORES G., MACARIO A. PALO, and BIENVENIDA R. RODULFO. Studies on thiamin and protein contents of some local yeasts. Philip. Jour. Sci. 87 (1958) 15–26.

5. LEACH, ALBERT E., and ANDREW L. WINTON. Food Inspection and Analysis. 4th edition. John Wiley and Sons Inc., New York (1936) xix + 1090 pp.

6. LOCHHEAD, A.G., and G.B. LANDERKIN. Nutrilite requirements of osmophilic yeast. Journ. Bacter. 44 (1942) 343–351.

7. MILLER, LASH W. Wildiers' Bios. Science 59 (1924) 197–199.

8. PRESCOTT, S. C., and C. G. DUNN. Industrial Microbiology. McGraw Hill Book Co., New York (1949) xii + 923 pp.

9. FAO, S. R., A. B. BHIMESWAR, and M. SCREENIVASAYA. Dept. Proc. 4th Inter. Cong. Microbiol., 1947. (1949) 562 pp.

10. SCHULTZ, A., L. ATKIN, and C. N. FREY. A fermentation test for vitamin B_1 Journ. Amer. Chem. Soc. 59 (1937) 948–949.

11. UNDERKOFLER, LELAND A., and RICHARD J. HICKEY. Industrial Fermentation. Chemical Publication Co., New York (1954) ix + 565 pp.

12. WILDIERS, E. Une nouvelle substance indispensable au development de la levure. La Cellule 18 (1901) 313. Cited by Tanner, Fred W. The "bios" question. Chem. Rev. 1 (1925) 397–472.

13. WILLIAMS, ROGER J., and ELIZABETH M. BRADWAY. The further fractionation of yeast nutrilites and their relationship to vitamin B and Wildiers' "bios." Jour. Chem. Soc. 53 (1931) 783–789.

14. WILLIAMS, ROGER J., R. E. EAKIN, and E. E. SNELL. The relationship of inositol, thiamin, biotin, pantothenic acid and vitamin B_6 on the growth of yeasts. Jour. Amer. Chem. Soc. 62 (1940) 1204–1207.

PHONEMES OF BATAK

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The Batak language is spoken by the Negritos living on the east coast of Palawan [1] the most western island of the Philippines. These people are in contact with the following languages: Tagbanwa, Cuyunon, Cagayancillo, and the National Language, Tagalog. Batak seems to be more closely related to Tagalog than to the others even though Cuyunon is the most widely used in the area. Very few Batak go to the local schools and these rarely stay longer than two years. A few men have a slight knowledge of English.

The data for this paper [2] was collected monolingually over a period of sixteen months between February 1956 and May 1959. There are three classes of phonemes [3] in Batak. Consonants: *b, k, d, g, l, m, n, ng,*[4] *p, r, s, t* and glottal stop.[5] Semivowels: *y* and *w*. Vowels: *a, i, e,*[6] *u*. Examples in this paper are written phonetically (indicated by brackets) only when they differ from the phonemic writing.

SYLLABLES

The syllable patterns of Batak may be indicated as follows: CV(C),[7] CSV(C), SV(C), V(C); or more concisely (C) (S) V(C). Each syllable thus contains a vowel nucleus with op-

[1] The Batak are found only in an area which extends north for forty miles from latitude 10°.

[2] The writer studied this language under the auspices of the Summer Institute of Linguistics and wishes to acknowledge her indebtedness to the Director of the Philippine Branch, Howard P. McKaughan, for his valuable assistance in the preparation of this paper.

[3] Stress and intonation appear to be closely related. A full analysis has not yet been attempted. However it has been observed that a primary (or word) stress tends to fall on the last of a two or three syllable sequence.

[4] The digraph *ng* has been used to represent the velar nasal following general Philippine usage.

[5] Glottal stop has been indicated as follows: on symbol word initial: a hyphen following a consonant: a grave accent mark on a vowel preceding the glottal stop.

[6] The symbol *e* has been used to represent the high back to central open unrounded vocoid.

[7] C = Consonant, V = Vowel, S = Semivowel, C or S in parentheses indicates that the occurrence is optional.

tional consonant or semivowel satellites. CV—*ka* 'you', CVC—*kat* 'construction marker', CSV—*gwa* 'only' CSVC—*mwat* 'come', SV—*a.sa.wa* 'spouse', SVC—*ni.wang* 'thin', V—*du.a* 'two', VC—*ta.eg* 'tell'.

Consonant-initial syllables can be combined in any order in a poly-syllabic utterance.[8] *sa.li.ang* 'comb' *rang.gas* 'stick', *sa.deng.sa.deng* 'conversation', *tan.se.kan* 'handle'; *be.gyas* 'basket', *da.gwa.na* 'not now', *mag.bwat* 'make', *ba.nwa* 'country', *pa.nya.'en* 'spirit', *mwat.ka* 'you come'. The occurrence of CV(C) syllables is far more frequent than that of SCV(C) syllables.

Non-consonant-initial syllables must always follow an open syllable. *ba.la.i* 'house', *sa.ra.ed* 'knees flexed', *ba.ya.wak* 'lizard', *i.a.i* demonstrative pronoun, *da.yam.dam* 'small animal', *du.a.teng* 'will leave'.

CONSONANTS

The thirteen consonant phonemes of Batak are voiceless and voiced stops, and nasals occurring at bilabial, alveolar, and velar points of articulation: *p, t, k; b, d, g; m, n, ng;* two liquids *l, r* (the *r* is flapped), and a slightly fronted sibilant *s* occur at the alveolar point of articulation; and a glottal stop. Examples are as follows:

Stop. *p. b; pila* 'bang', *bila* 'hook', *apu* kinship term, *abu* 'stove', *upus* 'wood already burning', *ubus* 'sufficient', *budbud* 'salt', *pudpud* 'cigar'; *t, d: tapu* 'head band', *dapu* 'orchid', *laut* 'crooked', *laud* 'lowland', *elat* 'wait', *elad* 'wing'; *k, g; kereng* 'curly', *gareng* 'back', *baka* 'cow', *baga* 'embers' *lebek* 'pound rice', *lebeg* 'arin'; glottal stop; *bura* 'bubble', *burak* 'flower', *apuk* 'dust', *ma'ula* 'pig', *ti'lug* 'egg'.

Nasals, *m; Manik* 'small beads', *ampang* 'word', *mata'mis* 'sweet', *udum* 'black cloud'; *n; nana* 'pus', *banwa* 'country', *indamar* 'tomorrow'; *ng; ngaran* 'name', *angbe* 'rat', *pungau* 'lonely', *galang* 'anklet'.

Sibilant. *s; siku* 'elbow', *asta* 'until', *palsawan* 'trap', *bakes* 'money'.

Liquids. *l, r; lubu* 'hole', *rubu* 'thousand', *tulu* 'three', *turu* 'water running down', *bulbul* 'feathers', *purpur* 'move'.

All consonants can occur initially and finally in the syllable. Consonant sequences occur only at the junction of syllables. The most frequent combinations are the sequence of nasal plus homorganic stop; *mp. mb. ngk, ngg, nt, nd.*[9] The following restrictions in consonant clusters have been noted: there are no nasal sequences; no stops except glottal and voiced velar

[8] Syllable divisions do not follow morpheme boundaries. *an le'gan* + is *le'.ga.nan.*

[9] Since such sequences always occur across syllable boundaries they are not considered a single unit.

precede a bilabial nasal; stops do not precede a nasal or a homorganic consonant.

SEMIVOWELS

The semivowels *y* and *w* are voiced high front and back non-syllabic vocoids. They contrast with the syllabic vocoids in such sequences as Cya(C) vs. Ci.a(C), and Cwa(C) vs. Cu.a (C). Note the following examples: *pa.nya.' en* 'spirit', *be.gyas* 'basekt'; vs. *i.li.am.beg* 'dropped', *si.a.la.an* 'blackened basket material'; *da.gwa.no* 'not now', *pag.sa.kwal* 'climb'. vs. *lu.a.ku.a.i* 'to cross a mat', *i.li.nu.ak* 'planted'. The distribution of the semivowels parallels that of the consonants since in the patterns SV(C) and CSV(C) the semivowels are satellite to the vowel nucleus. However, in the latter pattern, the semivowels occur in a unique position paralleling neither the consonants nor the vowels. It is further noted that the former of the two patterns mentioned above parallels that of the vowel initial syllables in its distribution since they both occur only following open syllables. Owing to the differences in distribution mentioned, the semivowels have been treated as a third class of phonemes (S).

In syllable patterns containing a semivowel both *y* and *w* may occur in the S position except that *y* has not been observed contiguous to *i* nor *w* contiguous to *u* or *e; y* has been observed to follow *p, t* and *n*; *w* following *p, b, k, g* and *m*.[10]

VOWELS

The four vowel phonemes of Batak are *a, i, e, u*. The phoneme *a* is a low central vocoid [11] tending to be little lower before back phonemes and higher before front phonemes. *dagwa* negative, *da'a* 'none', 'spouse', (*sakʌi*) *sakai* 'ride', (*'a'ʌi*) *'a'ai* 'foot', (*mʌyag*) *mayag* 'cleared ground'. The phoneme *i* is a high front vocoid varying from a close to an open position. *balai* 'house', *baliskeg* 'collar bone', *'ini* 'here'. The phoneme *e* varies from a high back open position to a central mid close position. The back position is the most common. *arek* 'smell', *selat* 'loud', *ke'deng* 'dog'. The phoneme *u* is a rounded back

[10] The sequence CS has not been treated as a single unit for it would unnecessarily overload the phoneme inventory, since all the consonants and semivowels involved occur as single units elsewhere.

[11] The mid front vocoid (*e*) only occurs in the following example (*'iei*) demonstrative pronoun, (*gieringan*) 'went' and has been taken to be an alternant of the phoneme *a*.

vocoid varying from a high open position to a mid close position. *aku* 'I', *aruk* 'swell', *sulạt* 'write'.

From a count of over 2,500 vowel phonemes in runnning text these approximate percentages have been noted: *a* 60 per cent, *u* 20 per cent, *i* 15 per cent and *e* only 5 per cent. The four vowels are found as the nuclei of all syllables except those in the form CSV(C) in which only *a* has been observed. The phoneme *e*, which has the lowest frequency, has not been found as a nucleus without satellites.

Vowel sequences of two or three are found at the junction of vowel nuclei. All of the two vowel sequences have been observed except **ea*, **eu*, and **ue*. The only sequences of three vowels found are *uai* and *iai*. Examples: *sialaan* 'blackened basket material', *maemeg* 'wet', *aibai* 'friend', *baklau* 'armlet', *laud* 'lowlands', *tuug* 'thread beads', *putïukan* 'bee', *iegṛeg* 'shiver', *geṭiek* 'little', *uanan* 'right side', *luakuai* 'to cross over a mountain', *pagiriai* 'take off'.

ILLUSTRATIVE TEXT

The following story is written to illustrate the phonemes in context.

Bayùu mai Bakes mamilà. (Turtle and Monkey go fishing.) *Na tu bakes, "Aibai mamilà ta."* (The monkey said, "Friend, let us go fishing.") *Ai na tu Bakes, "unu ipàen ta?"* (The monkey said, "What will we bait?") *Siàem kat bayùu tu tubu, siàem kat bakes tu punti.* (They caught sugar cane for the turtle and banana for the monkey.) *Nagawat tu bakes, "Magsambi ta aibai imu ini punti aken ini tubu."* (The monkey said, "Friend, let us exchange, you take the banana plant and I'll take the sugar cane.") *Nagsambi na sira ta pakabut tag balai ilinuak ya kat abu ilinuak it bayùu kat lugta tu punti.* (They exchanged and after reaching the house, he (the monkey) planted his in the stove and the turtle planted his in the ground.) *Iat ìinug na.* (It (the latter) ripened.) *Na tu baùu, "Panau ku sìi aibai pasakwalen tu punti ku?"* (The turtle said, "Will I be the one to go and climb my banana tree, friend?") *Na tu bakes, "Aku sìi."* (The monkey said, "I will be the one.") *Nagbaya na kat bayùu tu bakes.* (The monkey went with the turtle.) *Pagsakwal it punti pagkaabut ya dùun kat dibwat nagkàen na tu bakes.* (After climbing the banana tree and reaching the top, the monkey ate.) *Ta nagawat tu bayùu, "Aibai lambegan mu aku it ìinug kànen ku."* (The turtle said, "Friend, drop ripe ones to me, and I'll eat.") *Paganai it bakes kulitan itu punti a ìinug, iliambeg ya kat bayùu.* (Then the monkey peeled a ripe banana and dropped it to the turtle.)

SOME PARTICLES AND PRONOUNS IN BATAK

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The Batak language is spoken by a group of Negritos living about 65 to 100 kilometers north of Puerto Princesa on the island of Palawan in the Philippines. The purpose of this paper is to identify certain particles and pronouns in Batak and to indicate the grammatical relationships which they mark.

CASE-MARKING PARTICLES

1.1 *Definition.* Case-marking particles *tu, si; it, i ~ kai;* and *kat, kai* introduce substantial constructions and indicate caselike relations.[1]

1.2. *Impersonal particles.*

1.21. *The* tu *particle.* The particle *tu* marks the topic of a predication: *Magsulat* (*tu ibàiba mu*) *kat libru it ampang.*[2] (*mag*-write particle friend your particle book particle word) '(Your friend) is writing the word in the book.'; *Pagpanudayan it manuk* (*tu bilug ya*). (picking-lice-*an* particle chicken particle body his) 'It is (from his body) that the chicken is picking lice.' or 'The chicken is picking lice (from his body).'; *Pag-uyangyangen it uyag* (*tu kèdeng*). (teasing-*en* particle boy particle dog) '(The dog) is what the boy is teasing.', or 'The boy is teasing (the dog).'; *Ipianpadeket it tau kat dingding* (*tu papil*). (*i*-caused-to-stick particle man particle wall

[1] Cf. McKaughan, Howard. The inflection and syntax of Maranao verbs. Bureau of Printing, Manila (1958) 8 and 16, where he writes: "We refer to 'cases' since they are marked by inflection in pronouns, and extend the term to the same relations when marked by particles."

The writer wishes to acknowledge her indebtedness to Dr. McKaughan, Director of the Philippine Branch of the Summer Institute of Linguistics, for his valuable assistance in the preparation of this paper. Data for this paper was collected under the auspices of the Summer Institute of Linguistics by the writer and Rosemary Rodda. I wish to express appreciation also to the latter for access to her materials collected over a longer period of time than was available to me.

[2] For the phonemic analysis of this language see preceding article, "The Phonemes of Batak," by Rosemary Rodda.

particle paper) '(The paper) was what the man caused to stick to the wall.', or 'The man stuck (the paper) on the wall.'

When the topic precedes the verb this particle does not occur, the topic in this instance being marked by position and the absence of *tu:* *Magkàen* (*tu dugian*) *it amyas.* (*mag*-eat particle *dugian* particle *gabi*) '(The *dugian*) eats the *gabi.*'; (*Dugian*) *magkàe't amyas.* (*dugian mag*-eat particle /contracted form/ *gabi*) '(The *dugian*) eats the *gabi.*'

It will be noted that the topic of the above illustrations is related to the verb in different ways, i.e. actor, referent, object, accessory.[3] These different relations are determined by the different verb forms.

1.22. *The* it *particle.* The particle *it* indicates the *actor* and *object* in verbal relations[4] and *possessor* in nominal relations.

Actor. *Matawanan* (*it beken mi*) *tu ampang.* (know-*an* particle others your particle language) 'The language is known (by the others of you).'; *Pasublien* (*it anak*) *tu pasil ya.* (lend-*en* particle child particle top his) '(The child) lends his top.'; *Inimatai* (*it balbag*) *tu manga seda.* (*i*-caused-to-die particle hitting particle plural fish) '(The hitting) killed the fish.'

Object. *Timgis* (*it danum*). (*-m*-will-pour particle water) Someone will pour (the water).'; *Kài pinsian i Rinatu* (*it hayo*)? (where brought-*an* particle Rinatu particle wood) 'Where did Rinatu get (the wood)?'; *Unu ibales ku kanimu* (*it nagtaik it lambung ku*)? (what *i*-owe I you particle sewed particle clothing my) 'What do I owe you (for the sewing of my clothing)?'

When *it* introduces phrases functioning as actor and object in the same sentence, the first occurrence, immediately following the verb, is the actor and the subsequent occurrence the object (it being understood that such an occurrence is related to the verb rather than another substantive phrase): *Igpas* (*it tau*) *kat talun* (*it tandikan*) *tu lubid.* (*i*-trap particle man particle

[3] The term accessory was suggested by Elmer Wolfenden of the Summer Institute of Linguistics in connection with a Tagalog course conducted in Manila, 1958.

[4] This particle has been observed to occur utterance initial only in response to a vocal stimulus: Stimulus: *Mag-ampang ka.* (*mag*-speak you) 'You speak.' Response: (*It unu*)? (particle what) '(What) shall I speak?'

forest particle bird particle rope) '(The man) traps (the bird) in the forest with the rope.'

Possessor. tu ampang (*it batak*) (particle language particle Batak) '(the Batak's) language'; *it bulbul* (*it kuding*) (particle fur particle cat) '(the cat's) fur.'

1.23. *The* kat *particle.* The particle *kat* marks the *referent* of the action when related to the verb: *Magsulat kanya* (*kat libru*) *it ampang.* (*mag*-write she particle book particle word) 'She is writing the word (in the book).'; *Sakwalen mu* (*kat dibwat*). (climb-*en* you particle high) 'You climb (up high).'; *Iblad* (*kat pag-aldawan*). (*i*-dry particle sunshine) 'Put something to dry (in the sunshine).' The particle *kat* sometimes may also occur in sentences in which the topic (indicated by *tu*) is related to the verb as referent by a verbal voice marker. In this case the *kat* phrase indicates a further subordinate relation to the verb which may be temporal (or possibly instrumental): *Bayadan ku* (*kat duasun a linggu*). (pay-*an* I particle next particle week) 'I will pay (next week).'

This particle marks *location* when related to a preceding substantive phrase: *tu manga balabalai* (*kat enai*) (particle plural little-house particle beach) 'the little houses (on the beach)'.

1.3. *Personal particles.* Personal particles indicate that the word introduced is a title or name. These particles are *si, i* ~ *kai,* and *kai.*

1.31. *The particle* si. A *si* phrase [5] may replace a *tu* phrase functioning as topic of the predication: *Magsarap kat enai* (*si Iskwik*). (*mag*-catch particle beach particle Squeak) '(Squeak) is catching something on the beach.'; (*Si Wakin*)[6] *inisegan ya.* (particle Wakin was-angry-*an* he) '(It was Wakin at whom) he was angry.', or 'He was angry (at Wakin).': *Pàyùun mu* (*si Lulu*). (bathe-*en* you particle Lulu) 'You bathe (Lulu).'; *Iktang* (*si Panlangut*). *i*-fall article Panlangut) 'It will fall (with Panlangut).'

1.32. *The particle kai. Kai* phrases may replace *kat* phrases: *Nag-begai si Amadu it mais* (*kat babai*). (*mag*-gave particle Amadu particle corn particle woman) 'Amadu gave the corn (to the woman).'; *Nagbegai si Amadu it mais*

[5] The particle plus the word it introduces.

[6] When the topic precedes the verb the *si* occurs with the name or title introduced.

(*kai Guria*). (*mag*-gave particle Amadu particle corn particle Guria) 'Amadu gave the corn (to Guria).'; *Pisien mu tu martilyu* (*kat balai*). (bring-*en* you particle hammer particle house) 'You bring the hammer (to the house).'; *Pisien mu tu martilyu* (*kai Luis*). (bring-*en* you particle hammer particle Luis) 'You bring the hammer (to Luis).'; *Ipialang ku tu parai ku* (*kat lalaki*). (*i*-sold I particle rice my particle man) 'I sold my rice (to the man).'; *Ipialang ku tu parai ku* (*kai Velarde*). (*i*-sold I particle rice my particle Velarde) 'I sold my rice (to Velarde).'

Kai phrases may also replace *it* phrases when introducing an objective phrase: *Magtangis si Pining* (*it ibàiba ya*). (*mag*-cry particle Pining particle friend her) 'Pining is crying (for her friend).'; *Magtangis si Pining* (*kai Basilla*). (*mag*-cry particle Pining particle Basilla) 'Pining is crying (for Basilla).'; *Pagpatakutan ku kanya* (*it lalaki*). (causing-to-fear-*an* I her particle man) 'I am making her afraid (of the man).'; *Pagpatakutan ku kanya* (*kai Utun*). (causing-to-fear-*an* I her particle Utun) 'I am making her afraid (of Utun).'; *Itigad ku* (*it punti ku*). (*i*-cut I particle banana my) 'I cut (my banana).'; *Itigad ku* (*kai Guria*). (*i*-cut I particle Guria) 'I cut (Guria).'

1.33. *The particle* i. An *i* phrase may substitute for an *it* phrase only when functioning as actor or possessor.

Actor. Si Wakin inisegan (*i Padang*). (particle Wakin was-angry-*an* particle Padang) '(Padang) was angry at Wakin.'; *Ubrâen* (*i uà mu*) *maka.* (work-*en* particle brother you also) '(Your brother) works also.'; *Ituldu* (*i Maria*) *kanaken.* (*i*-teach particle Maria me) '(Maria) will teach me.'.

Possessor. Nanindeg tu bulbul (*i Pip*). (*maN*-stand particle fur particle Pip) '(Pip's) fur is standing up.'.

The particle *i* has an alternant *kai* which occurs when the phrase occurs first, alone, or alone in another phrase:[7] *pasil* (*i Usting*) (top particle Usting) '(Usting's) top', (*kai Usting*) *a pasil* (particle Usting particle top) '(Usting's) top',

[7] This parallels the difference in form (its absence) when a *tu* phrase occurs in the emphasis position. *Kai* phrases occur utterance initial in response to the question *Kasiung* ————? 'Whose ————?' Stimulus: *Kasiung pasil?* 'Whose top?' Response: (*Kai Usting*) *a pasil.* '(Usting's) top.'

(*kai Usting*) '(Usting's)'; *Magpasiar kat* (*kai Padang*). (*mag*-visit particle particle Padang) 'Someone will pay a visit to that which (belongs to Padang—[his house]).'

Note that the alternant of *i* is a homophone of the particle *kai* which introduces phrases that replace *kat* phrases. This alternant contrastively indicates possession, never functions as actor of a verb, and occurs in complementary distribution to *i* as described above. *Kat* phrases and their replacives with *kai* never function in such relationships. Further, the allomorph *kai* may occur within a *kat* phrases: *dìun kat* (*kai Arigan*) (there particle particle Arigan) 'there in (Arigan's) possession.'

1.34. *Plurals.* *Si, i,* and *kai* all indicate that the name or title introduced is singular. It has also been noted that when more than one person is referred to, particles indicating plural as well as case are used. The most frequent of these is *na* which has an alternant *kana*. This morpheme marks the plural of *i* ~ *kai:*

Actor. Piadketan (*i Nanawa*). (burned-off-brush-*an* particle Nanawa) '(Nanawa) burned off brush.', *Piadketan* (*na Nanawa*). (burned-off-brush-*an* particle Nanawa) '(Nanawa and her husband) burned off brush.'

Possessor. balai (*i amà mi*) (house particle father your) '(your father's) house', *balai* (*na amà mi*) (house particle father your) '(your father and mother's) house'; (*kai amà mi*) *a balai* (particle father your particle house) '(your father's) house', (*kana ama mi*) *a balai* (particle father your particle house) '(your father and mother's) house.'

One example has been noted of the plural of *si: kanasi.*[8] *Magtigbas* (*kanasi Maria*). (*mag*-clear-the-field particle Maria) '(Maria and those with her) are clearing the field.

PERSONAL PRONOUNS

2.1. *Definition.* Inflected polysyllabic free forms and monosyllabic clitics which may substitute for substantive phrases are called pronouns. The monosyllabic forms always follow the word to which they are related but only the polysyllabic

[8] A particle *kana*, indicating the plural of *kai* (the personal form of *kat*), seems possible although our present data does not show it.

forms may precede it.[9] Each form is inflected for person and number. Person consists of speaker and hearer or their absence. Number involves singular and plural.

Personal pronouns are more closely related to the personal particles *si, i ~ kai,* and *kai,* than to the impersonal *tu, it,* and *kat* since their distribution parallels the former exactly rather than the latter.

2.2. *Identification.*

Singular[10]

	Class I	Class II	Class III	
Speaker	*aku*	*ku ~ aken*	*kanaken*	'I'
Hearer	*ka ~ ikau*	*mu ~ imu*	*kanimu*	'thou'
Speaker and hearer	*ta ~ kita*	*ta ~ aten*	*kanaten*	'we two'
Neither	*kanya*	*ya ~ kanya*	*kanya*	

Plural

Speakers	*kami*	*men ~ amen*	*kanamen*	'we-not-you'
Hearers	*kamu*	*mi ~ imyu*	*kanimyu*	'you'
Speaker(s) and hearer(s)	*tami*	*tami ~ aten*	*kanaten*	'we all'
Neither	*sira*	*sira*	*kanira*	'they'

2.3. *Class I—Topic.* Class I pronouns substitute for substantive phrases introduced by *si* and always mark the topic of the verb: *Elatan mu* (*si Abuyut*). (wait-*an* you particle Abuyut) '(Abuyut is the one for whom) you are to wait.'; *Elatan mu* (*aku*). (wait-*an* you me) '(I am the one for whom you are to wait.', or 'Wait (for me).' This pronoun set when actor (as required by the voice of the verb) usually occurs (*1*) immediately following the verb: *Magsulat* (*aku*). (*mag*-write I) '(I) am writing.'; but it also may occur (*2*) preceding the verb for emphasis: (*Aku*)*sìi madal.* (I emphasis-particle *m*-study) '(I'll be the one) to study.'; (*Kanya*) *i nangayu.* (she particle *maN*-wood) '(She was the one) who went after wood.'; or (*3*) in a negative statement in which case the pronoun follows the negative: *Dàa* (*kamu*) *maglutu.* (no-longer you *mag*-cook) '(You) are no longer cooking.' In all other cases these pronouns follow the pronouns of set II:

[9] Where no monosyllabic form exists, the polysyllabic form occurs in either place. *Tami* of Class II occurs only following the word to which it is related.

[10] Cf. Thomas, David. Ilocano pronouns. Word 11 (1955) 204–208. McKaughan, Howard P. Semantic components of pronoun systems: Maranao. Word (1) 15 (1959) 101–102.

Taikan mu (*aku*). (sew-*an* you I) '(I am the one for whom) you sew.', or 'You sew (for me).'

2.4. *Class II—Actor—Possessor.* Class II pronouns consist of two sets of allomorphs: the first of the two follows the word to which it is related and the second precedes such a word or occurs in isolation in response to some stimulus. This distribution exactly parallels that of the personal particle *i* and its alternant *kai*.

2.41. *Actor. Piangaran* (*i Tèeng*) *tu kèdeng.* (caused-to-be-named-*en* particle Tèeng particle dog) '(Tèeng) named the dog.'; *Piangaran* (*ya*) *tu kèdeng.* (caused-to-be-named-*en* she particle dog) '(She) named the dog.'; *Isugid* (*mi*) *tu ubrà.* (*i*-tell you particle work) '(You) tell about the work.'; *Kài pinsian* (*i Rinatu*) *it kayu?* (where brought-*an* particle Rinatu particle wood) 'Where did (Rinatu) get the wood?'; *Kài pinsian* (*ya*) *it kayu?* (where brought-*an* he particle wood) 'Where did (he) get the wood?'.

2.42. *Possessor. tu ampang* (*i Amadu*) (particle word particle Amadu) '(Amadu's) word'; *tu ampang* (*ya*) (particle word his) '(his) word'; (*kai Amadu*) *a ampang* (particle Amadu particle world) '(Amadu's) word'; *tu* (*kanya*)*ng ampang* (particle his-ligature word) '(his) word.'

2.5. *Class III—Object—Referent.* Class III functions (*1*) as the referent substituting for the *kai* phrase: *Unu ibales ku* (*kai Velarde*)? (what *i*-owe I particle Velarde) 'What do I owe (to Velarde)?'; *Unu ibales ku* (*kanimu*)? (What *i*-owe I you) 'What do I owe (to you)?', Class III also (*2*) substitutes for the *kai* phrase functioning as object: *Nagkita ka* (*kai Bindilen*). (*mag*-tickled you particle Bindilen) 'You tickled (Bindilen).'; *Nagkita ka* (*kanaken*). (*mag*-tickled you me) 'You tickled (me).'; *Pagpatakutan mu kanya* (*kai Utun*). (causing-to-fear-*an* you her particle Utun) 'You are causing her to fear (Utun).'; *Pagpatakutan mu kanya* (*kanaken*). (causing-to-fear-*an* you her me) 'You are causing her to fear (me).'

When both the object and referent pronouns occur, both being of class III, the first is the object and the second the referent: *Magpisi ka* (*kai Karidad*) (*kai Guria*). (*mag*-bring you particle Karidad particle Guria) 'You bring (Karidad) (to Guria).'; *Magpisi ka* (*kanira*) (*kanamen*). (*mag*-bring you them us) 'You bring (them) (to us).'

SUMMARY OF RELATIONS[11]

Actor	Object	Referent	Accessory
it, i	*it, kai*	*kat, kai*	
ku	*kanaken*	*kanaken*	*kat, kai*

Note that any one of these relations may be replaced by *tu, si* or *aku* indicating the topic, if the voice of the verb so requires.

[11] Except where it has been specifically noted in the text, position does not seem to be fixed. Position may have grammatical significance in instances of ambiguity: i.e., sequences of two *kat* phrases. Further analysis is needed.

AN ECOLOGICAL SURVEY OF THE MARINE VEGETATION OF THE HUNDRED ISLANDS AND VICINITY

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INTRODUCTION

In an ecological survey of the marine vegetation of the Hundred Islands and their vicinities, the writer noted different types of habitats with different forms of vegetation. The muddy bottoms were found to be almost exclusively of Phanerogamic species of the genera *Posidonia, Thalassia, Diplanthera, Enhalus, Cymodocea,* and *Halophila.* A few of the Cryptogamic forms like *Halicoryne wrightii, Neomeris vanbossæ, Bornetella oligospora,* and *B. sphærica* were also noted in the same habitat attached to coral fragments or coral rocks and other hard substrata. In partly sandy-muddy bottoms, the dominant forms were *Halimeda opuntia* and few other species together with phanerogamic species of *Posidonia* and a few others. Brown and red algæ with some green forms of the genera *Caulerpa, Valonia, Halimeda* and a few others inhabited the sandy-rocky and coral reefs.

LUCAP BAY

Lucap Bay is the gateway to the Hundred Islands and their vicinities. With the exception of the canal for navigation within the bay, the rest of the place is shallow and almost bare at the lowest tide. The western part of the bay is very muddy with solid rock along the shoreline in many places. The cryptogamic vegetation of the place is extremely very poor, apparently owing to the deep muds deposited by the three rivers emptying into the Tambac Bay. Most of the places are without any vegetation, except further north toward the sea where tall eel-grasses *Posidonia* sp., low forms of *Enhalus acoroides, Thalassia hemprichii, Cymodocea isœtifolia, Cymodocea* sp., *Diplanthera univervis,* creeping *Halophila ovalis,* and another species are found. *Ulva reticulata* Forsk, a cryptogamic form, was noted although it is most probable that it was drifted only to the place.

The southeastern part of the bay about a mile and a half from the wharf has a better vegetation than the other side owing to the farther distance of the rivers flowing into the Tambac Bay. In this area the same phanerogamic vegetation found in the other side of the bay are found in a greater scale. The green alga *Halicoryne wrightii* Harv. grows luxuriantly covering extensive areas, being the dominant form during a certain part of the year. *Halimeda macroloba* Decaisne., *H. opuntia* (L) Lamour.; *Acetabularia major* von Martens, *Neomeris vanbossæ* Harv., *Bornetella oligospora* Solms-Laubach, and *B. sphærica* (Zanard.) Solms-Laubach are found in the place attached to harder substrata. The only brown alga encountered in this place was *Padina commersonii* Bory.

The northern part of the bay just in front of the wharf beyond 300 meters northward is shallow and bare at lowest tide. It is partly sandy-muddy with spotted areas of ell grasses composed of *Posidonia* sp., *Enhalus acoroides, Thalassia hemprichii, Diplanthera univervis, Cymodocea isœtifolia* and another species, apparently *C. serrulata* Aschers or *C. rotundata* Aschers; otherwise practically bare of any vegetation. There are no cryptogamic forms found in the place. The neighborhood of Alo Islet and Toritori Point are practically rocky and barren with very little vegetation, if any that might have escaped the writer's sight.

The northeastern part of the bay toward the Hundred Islands has a hardier bottom, partly sandy with scattered coral rocks and few small coral heads. Besides *Posidonia* sp., *Enhalus acoroides* and *Thalassia hemprichii* (Ehremb.) which were already noted in the other part of the bay, are several green algal forms represented by two species of *Halimeda opuntia* (L) Lamour. and *H. macroloba* Decaisne already noted from the southeastern region. Other algal forms encountered are *Ulva reticulata* Forsk., *Avrainvillea obscura* J. Ag., *A. erecta* (Berk.) A. Gepp & E. Gepp, *Padina commersonii* Bory, *Gracilaria lichinoides* and a couple species of *Sargassum* and *Caulerpa.*

PANAKALAN ISLET AND VICINITY

North of Lucap Bay about five miles from the wharf is Panakalan islet, less than a hectare in area. The surrounding areas are rich in marine vegetation. The tall eel grasses *Posidonia* sp., and the low form *Thalassia hemprichii* (Ehremb.)

are the most conspicuous vegetation. Several species of *Sargassum, Dictyopteris, Dictyota, Turbinaria, Padina, Caulerpa, Halimeda, Gracilaria, Halymenia,* and many others described in this paper were noted from this place.

TANDOYONG ISLET AND VICINITY

Beyond Panakalan Islet toward Bolinao Point is a bigger islet with about a dozen inhabitants. This islet, where a substation of the Pangasinan School of Fisheries is found, is noted for seaweeds, particularly *Caulerpa racemosa* var. *macrophysa* (Kütz.) Taylor, locally known as *ararocep,* which is brought to the Alaminos market in *tiklis* (large baskets) almost every afternoon preceding a market day for sale, to the public. *Hydroclathrus clathratus* (Ag.) Howe, locally known as *balbalolang,* is also used for food and marketed in the local market. On top of every basket of *Caulerpa* is placed *Hydroclathrus* apparently to cover the main bulk of the green seaweeds. During low tides more baskets of seaweeds are brought to the market.

From the islet particularly northward were collected many seaweeds. Among the phanerogamic forms are *Posidonia* sp., *Thalassia hemprichii* (Ehremb.) and *Halophila ovalis* (R. Br.) J. D. Hooker. Among the *Chlorophyta* are *Chlorodesmis comosa* Bail. and Harv., *Halimeda tuna* Lam. fo. *typica* Barton, *H. macroloba* Decaisne, *H. opuntia* (L) Lamour., different species of *Caulerpa, Valonia ventricosa* J. Ag., *V. confervoides* Harv., *V. utricularis* (Roth) C. A. Ag., *Bornetella oligospora* Solm-Laubach, *Avrainvillea obscura* J. Ag., *A. erecta* (Berk.) A. Gepp & Ethel Gepp, *Codium tenue* (Kütz.), *C. geppi* O. C. Schmidt, *Cladophora albida* (Huds.) Kütz., and *C. pellucida* Kütz. Among the *Phæophyta* are *Colpomenia sinuosa* (Roth) Derbes and Solier, *Hydroclathrus clathratus* (Ag.) Howe, *Padina commersonii* Bory, *P. australis* Hauck., *P. japonica* Yamada, *Dictyota dichotoma* (Huds.) Lamour., *D. divaricata* Lamour., *D. linearis* (Ag.) Grev., several species of *Sargassum,* and *Turbinaria.* Among the *Rhodophyta* are *Heterosiphonia* sp., *Melobesia farinosa* Lamour., two species of *Liagora divaricata* Tseng, *L. ceranoides* Lamour. fo. *leprosa* (J. Agardh) Yamada, *Galaxaura fastigiata* Decaisne, *G. squalida* Kjellman, *Gracilaria eucheumoides* Harv., *G. lichenoides* (L) Harv., *Jania tenella* var. *Zacæ* Dawson, and many others. The most conspicuous form attached to the distal half of the leaves of the

tall eel-grass *Posidonia* sp., is *Tolypiocladia condensata* (W. B. Silva). There is no tall eel-grass where this particular species of red alga cannot be found. They usually fill up the distal half of the eel-grass leaves with the long and soft thalli directed toward the direction of the current.

TELBANG COVE VICINITY

East of Lucap Bay beyond the mainland adjoining Hundred Islands is Telbang Cove which extends to Encarnada Point. It has a shallow shoal which during the lowest tide is usually bare. The deeper part toward Encarnada Point is an extensive growth of different *gassum* species; namely, *Sargassum sagamianum* Yendo, *S. serratifolium* C. Ag., *S. enerve* C. Ag., *S. giganteifolium* Yamada, *S. hemiphyllum* C. Ag., *S. Kjellmanianum* Yendo, *S. duplicatum* J. Ag., and many more which were already noted in other places already surveyed. Different species of *Padina* and *Halimeda* are next to the *Sargassum* in abundance. Few species of *Caulerpa* were also encountered. Species of *Hydroclathrus clathratus* (Bory) Harv., *Codium tenue* Kütz., *C. geppi* O. C. Schmidt, *Liagora divaricata* Tseng, *L. japonica* Yamada, *Valonia utricularis* (Roth) C. Ag., *V. confervoides* Harv., *V. ventricosa* J. Agardh, *Dictyota dichotoma* (Huds.) Lamour., *D. divaricata* Lamour., *D. Linearis* (Ag.) Grave., *Laurencia papillosa* (Forsk.) Grev., *Acanthophora spicifera* (Vahl.) Börg., *A. orientalis* J. Ag. and species of *Turbinaria ornata* (Turn.) J. Agardh, *T. conoides* (J. Ag.) Kütz., *T. trialata* (J. Ag.) Kütz., were also noted from the place. The phanerogamic vegetation of the extensive shoal is similar to those of the vicinities of Panakalan and Tandoyong islets, being mostly of the tall and short eel-grasses. Thorough survey of the place may reveal more cryptogamic forms.

HUNDRED ISLANDS

The Hundred Islands, now one of the national parks of the Philippines, include many small volcanic islets which together with rocks above the water may number over four hundred. The majority of the islets are separated by deep channels although there are quite a number of place with shallow coral reefs. The marine vegetation of the group is not so rich in quantity compared with those of the Panakalan and Tandoyong vicinities, although many of the forms encountered are also found with several other forms not encountered elsewhere.

Among the algæ found only in the place are *Cheilosporum cultratum* (Harv.) Aresh., *Eucheuma gelatinæ* (Esp.) J. Ag., *E. okamurai* Yamada, *E. striatum* Schmitz, *E. muricata* (Gmel.) W.v.B., *E. spinosum* (L.) J. Ag., E. *muricatum* f. *depauperata* W.v.B., *Mastophora rosea* (C. Ag.) Setch., *Stypopodium flavelliforma* W.v.B., *Titanophora weberæ* Borg., *Galaxaura fastigiata* Decaisne, and *G. fructiculosa* Kjellman. Most of the seaweeds collected from this area were from the vicinities of the Shell, Devil's Kitchen, Quezon, and Murphy Islands.

PHANEROGAMIC FORMS
(Flowering plants)

POTAMOGETONACEÆ

CYMODOCEA ISOETIFOLIA

With cylindrical slender leaves.

Locality: Lucap Bay on muddy bottom.

CYMODOCEA sp.

With broad and flattened leaves, 3 mm wide and 110 mm long.

Apparently *C. serrulata* Aschers if not *C. rotundata* Aschers.

Locality: Lucap Bay on muddy bottom.

DIPLANTHERA UNIVERVIS (Forskal.) Ascheron

Zostera uninervis (Forskål) (1775) Red Sea.

Resembling *Cymodocea* with narrow flattened leaves.

Locality: Lucap Bay on muddy bottom with grasslike habit.

HYDROCHARITACEÆ

ENHALUS ACOROIDES Steud.

Resembling *Thalassia hemprichii* in some respects.

Locality: Lucap Bay on muddy bottom.

HALOPHILA OVALIS (R. Br.) J. D. Hooker (1860) (Tropical Australia).

Caulinia ovalis R. BROWN (1810).

With oval leaves and 11 to 14 small veins.

Locality: Lucap Bay on muddy bottom.

HALOPHILA sp.

Resembles *Halophila ovalis* except that leaves narrower and longer with 16 to 20 secondary pinnate veins. Apparently *H. spinulosa* Aschers.

Locality: Lucap Bay in sandy muddy bottoms.

THALASSIA HEMPRICHII (Ehremb.) Ascherson (1875) (Red Sea).

Schizotheca hemprichii (Ehremb.) ASCHERSON (1832).

A monocotyledonous perennial herb, with upright shoot of 10 to 39 cm high, and are borne by rhizomes at 18 centimeters apart. With usually 3 to 5 strap-shaped leaves that are crowded and distichous.

Locality: Lucap Bay on muddy bottom, and other places around Panakalan, Tandoyong Islets and Telbang Cove.

POSIDONIA sp.

With long flattened leaves, some over a meter long and an inch wide.

Locality: Lucap Bay on muddy bottom, and the neighborhood of Panakalan, Tandoyong Islets, and Telbang Cove, etc.

CRYPTOGAMIC FORMS

CYANOPHYTA

(Blue-green algæ)

RIVULARIA sp.

Colony on rocks, stones and other algæ. Thallus hemispherical.

Locality: Tandoyong Islet on sandy flat, and between tide marks.

SYMPLOCA sp.

Colony brownish, erect pointed tufts attached to rocks.

Locality: Tandoyong Islet like preceding.

CHLOROPHYTA

(Green algæ)

AVRAINVILLEA ERECTA (Berk.) A. Gepp. et E. S. Gepp (1911).

Dichonema erecta BERKELEY (1842) Philippines.

With large massive stalk usually buried in mud. Filaments compacted of softer texture.

Locality: Lucap Bay on sandy flat and sandy-muddy bottom.

AVRAINVILLEA LACERATA Agardh f. ROBUSTIOR A. Gepp et E. S. Gepp.

Resembles the preceding with filaments compacted and flabellated.

Locality: Tandoyong Islet on sandy-muddy bottom.

ACETABULARIA MAJOR von Martens.

Disk composed of 70 to 90 sporangia. Diameter of disk 8 to 15 mm with long cylindrical, slender calcified stalk 30 to 50 mm long.

Locality: Same habitat as *Neomeris vanbossæ* attached to dead coral fragments. Apparently medicinally used for renal calculi, gall stone, and bladder stones.

ACETABULARIA sp.

Very tiny species with disk 2 to 3 mm diameter composed of 27 to 30 sporangia, with slender stalk 3 to 5 mm long.

Locality: Attached to coral boulders and coral fragments among coral reefs.

BORNETELLA OLIGOSPORA Solms-Laubach (1893).

In life, greenish in color, cylindrical with fine filaments at distal tip.

Locality: Southeastern Lucap Bay, Tandoyong neighborhood and other places attached to coral rock fragments in sandy-muddy bottom.

BORNETELLA SPHÆRICA (Zanard.) Solms-Laubach.

Neomeris sphærica Zanardini.

Spherical frond attached to coral fragment and coral rocks. Color green and show distinctly the cells.

Locality: Many places in the Hundred Islands vicinity.

BORNETELLA OVALIS Yamada.

Similar to the preceding except in form with distinct pear-shape. Apparently of the same species.

Locality: Same as preceding.

CAULERPA RACEMOSA var. MACROPHYSA (Kützing) Taylor (1928).

Chauvinia macrophysa KÜTZING (1857) (Central American).

Ramuli expand rather suddenly into spherical, 3 to 5 mm in diameter, and from 3 to 5 mm apart.

Locality: Tandoyong islet and several neighboring places on sandy rocky bottom. The most abundant variety and commercialized locally. Eaten raw in the form of salad.

CAULERPA LENTILLIFERA J. Agardh.

Caulerpa longistipitata (W.v.B.) SVEDELIUS (1906).

With long frond, constriction of ramulus pedicel, and long pedicels. Ramuli multiseriate arrangement, resembling bunches of grapes.

Locality: Tandoyong Islet on sandy rocky bottom. It resembles to some extent to a Japanese species *Caulerpa okamurai*. Very fleshy and juicy when pressed. Same use as preceding.

CAULERPA RACEMOSA var. OCCIDENTALIS (C. Ag.) Börgesen.

Ramuli alternate and somewhat distichous, not crowded and suddenly swollen into rounded tip from a fairly long pedicel.

Locality: Tandoyong Islet and neighboring places on sandy-rocky bottom. Same use as preceding.

CAULERPA SERRULATA (Forsk.) J. Ag. emend. Börgesen (1932).

Fucus serrulatus FORSKÅL (1775) (Red Sea).
Caulerpa freycinetii C. AGARDH (1882); W.v.B. (1898); SVEDELIUS (1906); OKAMURA (1913).
C. serrulata J. AGARDH (1836); TSENG (1936a).

Locality: Tandoyong Islet and neighboring places on sandy-rocky bottom. Also edible and eaten in the form of salad.

CAULERPA CUPRESSOIDES (Vahl.) C. Agardh.

Fucus cupressoides VAHL. (1802).
Caulerpa cupressoides (Vahl.) C. AGARDH (1822); J. AGARDH (1872); W.v.B. (1898); SVEDELIUS (1906); BÖRGESEN (1913); OKAMURA (1916); TAYLOR (1928); TSENG (1936a).

Locality: Tandoyong, Panakalan Islets on sandy-rocky bottoms. Same use as preceding.

CAULERPA CUPRESSOIDES var. ERICIFOLIA (Turn.) W. v. B.

Locality: Tandoyong, Panakalan and Hundred Islands on sandy-rocky bottoms. Same use as preceding.

CAULERPA SERTULARIOIDES (Gmelin.).

Fucus sertularioides GMELIN (1768).
Fucus plumaris FORSKÅL (1775).
Caulerpa plumaris (Forskål) C. AGARDH (1822); KÜTZING (1849); DICKIE (1876); W.v.B. (1898).
Caulerpa sertularioides (Gmelin) HOWE (1905); SVEDELIUS (1906); BÖRGESEN (1907); VICKERS (1908); COLLINS (1909); W.v.B. (1913); OKAMURA (1913); YAMADA (1934); TSENG (1936a).

With more and shorter ramuli, 15 to a centimeter and 0.5 to 0.7 cm long, and fronds reach a height of 4.0 cm, with a very soft appearance.

Locality: Tandoyong, Panakalan and Hundred Islands and vicinity on sandy-rocky bottoms. Same use as preceding.

CAULERPA SERTULARIOIDES (Gmelin) Howe f. LONGISETA (Bory) Svedelius.

C. sertularioides f. longiseta (J. Agardh) Svedelius.
C. plumaire var. *β longiseta* Bory.

Ramuli are 10 to 11 or more to a centimeter and up to 1.0 cm long and in which fronds may reach a height of 9.0 cm.

Locality: Same as preceding.

CAULERPA BRACHYPUS Harvey.

With single or duplex large finely, irregularly serrated leaf-like fronds arising from crustose thallus, and at base of some fronds a round sponge structure. Resembling partly to *C. prolifera* (Forsk.) Lamour.

Locality: Tandoyong Islet on sandy-rocky bottom.

Too delicate and small for food and rather rare.

CLADOPHORA PELLUCIDA Kütz.

Branching regularly di-trichotomous with two or more branchlets arising at each articulation. Tufts 4 to 15 cm long; filaments rigid and erect.

Locality: Panakalan Islet on rock surfaces. Also used for food particularly for milkfish in brackish-water pond culture.

CLADOPHORA ALBIDA (Huds.) Kützing (1843).

Conferva albida HUDSON (1778) (Great Britain).

Branching irregular, penultimate ramuli long, potent, blunt, usually opposite. Cells 4 to 5 times as long as broad, cylindrical.

Locality: Tandoyong Islet on rock surfaces. Same use as preceding.

CHAETOMORPHA CRASSA (Ag.) Kützing (1845).

Chætomorpha torulosa KÜTZING (1845).
Conferva linum Harv. non alior.
Conferva crassa C. AGARDH (1824) (Adriatic Sea).

Filaments thick, of great length, light or dark green according to age, much curled, rigid, usually loosely entangled.

Locality: Panakalan Islet and neighboring places entangled with *Ulva reticulata*. Same use as preceding.

CHAETOMORPHA TORTA McClathie.

Locality: Panakalan Islet on some other algæ. Same use as preceding.

CHLORODESMIS COMOSA Bail. and Harvey.

Dense tuft of brightly green short filaments.

Locality: Tandoyong Islet on coral fragments and rocks.

CODIUM TENUE Kützing.

Thalli irregularly dichotomously branched and cylindrical. Partly greenish and spongy texture.

Locality: Tandoyong Islet on sandy bottom and coral fragments. Eaten raw in form of salad.

CODIUM GEPPII O. C. Schmidt.

Dichotomously branched and dark green in life. Stumpy and somewhat flattened thalli or spongy texture.

Locality: Tandoyong Islet on sandy bottom and coral fragments. Same use as preceding.

DICTYOSPHÆRIA CAVERNOSA (Forskål) Börgesen (1932).

Ulva cavernosa FORSKÅL (1775).

Dictyosphæria favulosa (Mert.) Decaisne.

Hollow, burst open irreguarly lobed thallus, globular when young.

Locality: Tandoyong Islet on rock on sandy bottom among coral reefs.

DICTYOSHÆRIA VERSLUYSII Weber van Bosse.

Resembles the preceding but solid even when old.

Locality: Tandoyong Islet on the same habitat as preceding.

HALIMEDA OPUNTIA (L) Lamouroux (1816).

Corallina opuntia LINNÆUS (1758) (Mediterranean Sea).

Forming congested clumps usually detached from anchorage, and highly calcareous.

Locality: Lucap Bay, Hundred Islands, Panakalan and Tandoyong Islets and all neighboring places on sandy muddy and sandy bottoms. Most abundant in the region.

HALIMEDA TUNA Lam. f. TYPICA Barton.

Root more-or-less bulbous; lowest joint cylindrical or luneate, deeply calcified. Other joints mostly reniform, flat and discoid or transversely oblong, not ribbed, margin entire.

Locality: In many places like that of *H. opuntia* on sandy bottom among coral reefs.

HALIMEDA MACROLOBA Decaisne.

Resembles slightly to *Halimeda gigas* in size but thickly calcified as in *H. tuna* Lam. f. *typica* Barton. Branching in one plane. Uniformly calcified. Joints flat and rounded. Color in life green.

Locality: Same as that of the preceding, on sandy bottom among coral reefs and eel-grasses.

HALIMEDA GIGAS Taylor.

Lowest joint somewhat cylindrical; fronds thinly calcified, greenish and thin. Other joints mostly discoid and reniform.

Locality: In many places in the vicinity of the Hundred Islands.

HALICYSTIS OVALIS Areschoug.

Valonia ovalis C. A. Agardh.

Thallus solitary and globular with penetrating rhizoidal prolongation to substratum. Largest measures 40 mm high and 30 mm broad.

Locality: In Lucap Bay toward open sea, Hundred Islands, Panakalan and Tandoyong Islets, attached to rocks on sandy bottom among coral reefs.

HALICORYNE WRIGHTII Harvey.

Thallus slender with from 20 to 70 whorls of sporangia arranged in series. Calcareous. Several thalli spring up from a common area. Thalli from 30 to 100 mm high and 2 to 55 mm diameter.

Locality: Southeastern Lucap Bay. Attached to rock, stone and dead coral fragments in muddy bottom. The most dominant form in the area growing in clusters.

NEOMERIS VANBOSSÆ Harvey.

In life, whitish with tip greenish. Cylindrical and more slender. Partly calcareous.

Locality: Southeastern Lucap Bay and the extensive sandy-muddy flat of the Northern area. Attached to dead coral fragments. Bright yellow-green tips conspicuous. Lower part white and calcified.

ULVA RETICULATA Forskål.

Frond reticulated and somewhat perforated, greenish in color. Oftentimes drifted and cast ashore in big numbers.

Locality: Widely distributed and most abundant everywhere, drifting or attached to bottom in sandy coral reef region.

Apparently good for food and fertilizer, but not actually used locally.

ULVA PERTUSA Kjellman.

Frond variously shaped, usually ovate-lanceolate, stipes distinct and solid, later irregularly divided.

Locality: Hundred Islands vicinity.

VALONIA CONFERVOIDES Harvey.

Frond consisting of branched cœnocyte attached to substratum by rhizoids forming a colony. Thalli slender and irregularly branched.

Locality: Tandoyong and Hundred Islands on coral fragments in sandy bottom.

VALONIA VENTRICOSA J. Agardh (1887).

Frond consisting of a simple globular cœnocyte attached to substratum by rhizoids.

Locality: Tandoyong Islet on small rocks and fragments.

VALONIA UTRICULARIS (Roth) C. A. Agardh.

Branched cœnocyte stout with tips of each terminal branch bulbular.

Locality: Tandoyong Islet on small coral rocks and fragments.

PHÆOPHYTA

(Brown algæ)

COLPOMENIA SINUOSA (Roth) Derbes and Solier (1856).

Ulva sinuosa ROTH (1806) (Cadiz, Spain).

In few cases they suggest different species. Dawson, 1954, claimed that in spite of variability they cannot satisfactorily be separated into specific units. The smooth, rounded form is considered typical form of the species *C. sinuosa,* recognizable by its brown, bubblelike shape. Other forms form a considerable range, tuberculate, lobed, contorted, and perforated, approaching *Hydroclathrus,* to which they are closely related. They may be used as food in the form of salad; and also as sources af algin or sodium alginate.

Locality: In many places in the region from Tandoyong to the Hundred Islands on small coral rocks and fragments on sandy bottom.

DICTYOPTERIS UNDULATA (Holmes) Okamura (1932).

Neurocarpus undulata HOLMES (1936).

Young plant resembles *Sargassum patens* C. Ag. var. *Schizophylla* Yendo to some extent. Fronds with definite growth, with flattened thallus. With elevated rib along median line of frond with lateral costal lobes if any. Vesicles elliptical, obovate or subspherical with a complanated stalk. Receptacles linear and simple or often forked and blunt at apices. Radial fronds simple or pinnately lobed, thin, membranaceous, provided with midrib and irregular rows of cryptostomata. Margin of simple fronds acutely dentated.

Locality: Panakalan Islet and vicinity on sandy coral rocks among coral reefs attached to the bottom. Same use as *Sargassum.*

DICTYOTA DICHOTOMA (Huds.) Lamouroux (1809).

Ulva dichotoma HUDSON (1762) (England).

Thallus flattened, membranous and dichotomously branched. Segments without a midrib. It grows over 10 cm tall; the widest segments measures 5 to 7 mm.

Locality: Attached to coral rocks on sandy bottom, others drifting and some cast ashore in Panakalan and Tandoyong Islets. Apparently good for food but not actually used locally. Also good as fertilizer, and as a source of algin or sodium alginates.

DICTYOTA DIVARICATA Lamour.

Thallus dichotomously branched and very narrow, widest measures only 1 mm. Like preceding, it grows also over 10 cm tall.

Locality: Same as preceding. More tender than *D. dichotoma*. Same use as preceding.

DICTYOTA LINEARIS (Ag.) Grev.

Thallus irregularly dichotomously branched and very narrow, almost cylindrical measuring 0.5 mm wide. Apparently the smallest species of *Dictyota*.

Locality: Apparently same place. Found with some other algæ. Not common and easily missed because of its fine size. Same use as preceding.

HYDROCLATHRUS CLATHRATUS (Ag.) Howe (1920).

Encoelium clathratum C. AGARDH (1822) (Bell Isle, France).

Thallus reticulate forming a network of different sizes of perforations, not uniform in size, some course and others fine.

Locality: In shallow water in many places very abundant in summer time (April to May). Used as food and eaten raw as salad. Many seen drifting in deeper water. A good source of alginic acid or sodium alginate.

LEATHESIA DIFFORMIS (Linnæus) Areschoug.

Thalli yellowish-brown in color. Young thallus subspherical and solid, later irregularly convulated and hollow.

Locality: Tandoyong Islet on sandy bottom.

PADINA AUSTRALIS Hauck (1887).

With erect, broadly flabelliform fronds often split into many flabellate segments and covered with brownish hairs to the middle, with hair lines conspicuous. Color light olivaceous, yellowish brown.

Locality: In many places from Tandoyong to Telbang Cove beyond Hundred Islands on sandy coral rock bottom attached to substratum. Like other brown seaweeds it may be used as food in the form of salad and as source of algin or sodium alginate.

PADINA COMMERSONII Bory (1828).

Small, thin membraneous, flabelliform fronds, with somewhat auricular lobes at both ends of entire frond. Also often split into many segments, thinly calcified on lower surface. Hair lines conspicuous. Color between rusty and buffy tinges.

Locality: Same as preceding. Apparently same use as preceding.

PADINA JAPONICA Yamada.

Small, thin, flabelliform, shortly stipitate, stupose at base, often split into several segments. Segments entire at margin, sometimes shallowly split. Interpillar spaces usually narrow. Color light yellowish brown with olivaceous shade.

Locality: Same as preceding. Same use as preceding.

POCOCKIELLA VARIEGATA (Lamx.) Papenfuss (1943).

Gymnosorus collaris (C. Agardh) J. AGARDH (1936).
Dictyota variegata (Lamouroux.
Zonaria variegata (Lamour.) C. Agardh.

Thallus oval leaflike with one side attached to coral fragments; thin flattened and firmed.

Locality: Hundred Islands. Attached to some coral fragments and rocks. Same use as preceding forms.

SARGASSUM CONFUSUM Agardh.

Leaves large and more spatulate or obtuse and somewhat serrated. Vesicles abundant and do not vary much in shape, either ellipsoidal or often pyriform with a very short stripe. Receptacles elongato-conical, with short pedicel.

Locality: Hundred Islands and vicinity on sandy coral rock bottom usually attached on rocks. Same use as other species of *Sargassum*.

SARGASSUM GIGANTEIFOLIUM Yamada.

It resembles *Sargassum serratifolium* J. Ag. to some extent and differs in different arrangement of receptacles and absence of long narrow leaves on upper portion. The very much larger leaves on the lower portion of frond make it more easily distinguished from other species.

Locality: Hundred Islands and vicinity among coral reefs and usually attached to coral rocks. Although not actually eaten by the people, it may be used as food like other brown seaweed. It is a good source of algin or sodium alginate, potash, carbonate of soda, and iodine. It is also recognized as medicine among the Chinese in the Islands.

SARGASSUM HEMIPHYLLUM C. Agardh.

Fucus hemiphyllus Turn.
Spongocarpus hemiphyllus Kg.
Sargassum hemiphylloides Kg.
S. hemiphyllum var. *sinense* J. Ag.
S. hemiphyllus var. *micromerum* J. Ag.
S. micromerum J. Ag.
S. sinense J. Ag.

Leaves of lower frond cuneate, obovate or oblongo-elliptical, and minutely serrated, frequently symmetrical. Leaves of upper frond usually asymmetrical and vertically situate, and obliquely cuneate, attenuated to a short filiform petiole. Vesicles abundantly provided on lateral branches mostly on lower portions. Receptacles cylindrical, more or less attenuated upward and tapered abruptly to a short pedicel.

Locality: Hundred Islands and vicinity among coral reefs and attached to coral boulders. Same use as other species of *Sargassum.*

SARGASSUM KJELLMANIANUM Yendo.

Sargassum corynecarpum (non Harv.) J. Ag.
Spongocarpus enervis (non KÜTZ.) Martens.

According to Yendo this species has apparently a close resemblance to *Sargassum hemiphyllum* in its general aspects, but it may readily be distinguished from latter species by its scutate disc, forms of leaves and by less numerous *vesicles.* On the other hand, *Sargassum thumbergii* f. *latifolia* Yendo has an external resemblance with present species. When young shoots of both plants almost indistinguishable but differ a great deal when fully grown exhibiting several distinguishing characters.

Locality: Hundred Islands and vicinity among coral reefs attached to rocks. Same use as other species of *Sargassum.*

SARGASSUM SERRATIFOLIUM C. Agardh.

Fucus serratifollium C. Ag.
Fucus longifolius var. *tenuifolia* Turn.
Halochloa longifolia Kütz.
H. serratifolia Kütz.

H. serratifolia var. *longifolia* Kütz.
Fucus longifolius Turn.
Sargassum corynecarpum Harv. (nec. J. Ag.).

According to Okamura this species varies in appearance with season and condition of environment, often very difficult to distinguish from *Sargassum tortile.* It may be differentiated from the latter species by its characteristic duplicate-serrated leaves. Leaves vary in size and shape according to their position. Basal leaves ovate, oblong or spatulate, and irregularly dentate at margin. Gradually upwards, leaves become elongated and narrowed and linear spatulate or linear lanceolate, serrated with shallow sinuses. Those on ultimate ramules become almost filiform. Air vessels larger and more spherical in lower portion of frond, while smaller and more elliptical or almost fusiform upwards. Receptacles are complanated, blunt at apex or often attenuated above and tapered below into a short slender stalk.

Locality: Hundred Islands and vicinity among coral reefs and attached to coral rocks. Same use as other species of *Sargassum.*

SARGASSUM NIGRIFOLIUM Yendo.

Very distinct forms which can be differentiated from other forms in color, its vesicles and receptacles. Color blackish brown. Vesicles usually formed solitary on basal portion of lateral branches and subcompressed, elongate elliptical. Receptacles mostly solitary at each axil leaf, spatulate or subcuneate.

Locality: Hundred Islands and vicinity. Usually attached to coral rocks between tide-marks. Same use as other species of *Sargassum.*

SARGASSUM DUPLICATUM J. Agardh.

Sargassum ilicifolium var. *duplicatum* J. Ag.
Sargassum cristæfolium Harv.

Easily differentiated by margin of leaf, often duplicated in robust form provided with toothed lobules arising from intramarginal surface. Air vesicles spherical and not abundant. Receptacles less densely aggregated in cymose manner and frequently isolated by a short stalk, both toothed and unarmed receptacles present. Frond fleshy and apparently best source of algin.

Locality: Tandoyong Islets and vicinity in sandy coral rock bottom. Same use as other species of *Sargassum.*

SARGASSUM YENDOI Okamura et Yamada (Yamada 1938).

Leaves in lower portion of stem either simple or decompound pinnate with lanceolate or linear lanceolate lobes. Upper portion of stem subterete or compressed with rounded margin. Vesicles spherical without cryptostomata. Receptacles simple or divided, racemosely arranged in spiral manner on ultimate ramulet.

Locality: Same as preceding.

SARGASSUM FULVELLUM Agardh.

Sargassum enerve C. AGARDH (1936) 335.

Leaves elongated and serrated of medium size. Resembles *S. serratifolium* to some extent. Receptacles less densely aggregated and frequently isolated.

Locality: Many places in the vicinity of the Hundred Islands.

TURBINARIA ORNATA (Turn.) J. Agardh (1848).

Fucus turbinatus var. *ornatus* TURNER (1808).

Leaves large and fleshy, circular, concave with two prominent ridges and prominently serrated.

Locality: Hundred Islands and vicinity on sandy coral rock bottom usually attached to coral rocks, and forms dense colonies. Same use as all species of *Sargassum.*

TURBINARIA CONOIDES (J. Agardh) Kützing.

Leaves medium size, shield-shape, concavo-convex, and serrated.

Locality: Same as preceding on sandy coral rock bottom, attached to coral rock. Same usage as other species of *Turbinaria* and *Sargassum.*

TURBINARIA TRIALATA (J. Agardh) Kützing.

Leaves small, semilunar, somewhat concavo-convex and sparsely serrated.

Locality: Same as preceding in same habitat, and same usage.

STYPOPODIUM FLABELLIFORME W.v.B.

Flabelliform, broad, leaflike fronds attached to coral rocks.

Locality: Hundred Islands among coral reefs.

RHODOPHYTA

(Red algæ)

ACANTHOPORA SPICIFERA (Vahl.) Börgesen (1910).

Fucus spiciferus VAHL. (1799).

Locality: Hundred Islands and vicinity among coral reefs.

ACANTHOPORA ORIENTALIS J. Agardh.

According to Dawson (1954) it is probably same species as preceding species recorded by Reinbold.

Locality: Hundred Islands and vicinity.

AMANSIA GLOMERATA C. Agardh.

With flat leaflike frond made up of horizontal rows of very regular cells.

Locality: Hundred Islands and vicinity among coral reefs.

AMPHIROA FRAGILISSIMA (Linn.) Lamour. (1816).

Corallina fragilissima LINNÆUS (1767).

Thalli saxicolous, finely tufted, 4 to 6 cm high, consisting of abundantly branched primary branches irregularly branching dichotomously; segments calcified, cylindrical, somewhat fragile and delicate.

Locality: Hundred Islands and vicinity attached to rocks and coral fragments.

AMPHIROA ANNULATA Lemoine.

Thalli tufted to 20 mm high consisting of many cylindrical segments, dichotomously branched and prominently annulate throughout. Color purplish pink.

Locality: Hundred Islands attached to rock fragments.

AMPHIROA SUBCYLINDRICAL Dawson.

With erect saxicolous thalli coarsely tufted 6 to 7 cm high, with few abundantly branched primary branches, branching irregularly dichotomous. Segments heavily calcified, cylindrical or subcylindrical. Smooth at distal and roughened at basal region.

Locality: Hundred Islands attached to rocky substratum.

CERAMEUM MARYÆ Weber van Bosse (1923).

Locality: Panakalan Islet and vicinity attached to coral fragments among Alcyonarians and on larger algæ.

CENTROCERAS sp.

Attached to Alcyonarians and coral fragments.

Locality: Panakalan Islet and vicinity.

CHEILOSPORUM CULTRATUM (Harv.) Aresch.

Thalli saxicolous to 5 cm high, consisting of several to many much branched erect parts from a crustose basal stratum; primarily compressed or flattened, much broader than long with prominent wings and midrib, mostly 2 mm wide, and 1 mm

long. Distinctly calcified. Natural color pinkish and turned white in preserved state.

Locality: Devil's Kitchen Island of the Hundred Islands attached to its eroded base forming a part of the fringing reef.

EUCHEUMA GELATINÆ (Esp.) J. Agardh.

Thalli fleshy, branched, smooth.

Locality: Hundred Islands among fringing reefs of some islets. Used as food in the form of salad as well as in making some agar-agar dessert.

EUCHEUMA SPINOSUM (Linn.) J. Agardh.

Thalli fleshy, branched, similar to the preceding species but spinous.

Locality: Hundred Islands among fringing reefs of some islets. Same use as preceding.

EUCHEUMA MURICATA (Gmel.) Weber van Bosse.

Thalli fleshy, branched irregularly and somewhat tubular.

Locality: Hundred Islands and in the vicinity around Tandoyong Islet. Same use as preceding.

EUCHEUMA MURICATUM f. DEPAUPERATA Weber van Bosse.

Resembles preceding but with most prominent spinous branches.

Locality: Hundred Islands among fringing reefs of some islets. Same use as preceding.

EUCHEUMA STRIATUM Schmitz.

Thalli fleshy, irregularly branched and somewhat spinous. Distal tip spinous and sharply truncated.

Locality: Hundred Islands as well as in Tandoyong Islet. Same use as preceding.

EUCHEUMA OKAMURAI Yamada.

Thalli very fleshy, branches united and fused together near base. Distal branches somewhat spinous. Natural color pinkish.

Locality: Hundred Islands and Tandoyong vicinity. Same use as preceding.

GALAXAURA FASTIGIATA Descaisne (1842).

Galaxaura Schimper Descaisne.

Frond fragile, smooth, dichotomously branched and thickened toward apex; loosely corymbose or almost semiglobose; wide axils and cylindrical or somewhat distended internodes. Color purplish red to brownish red.

Locality: Tandoyong Islet and Hundred Islands and vicinity among coral reefs.

GALAXAURA FRUTICULOSA Kjellman.

Frond cæspitose and loosely fruticulescent, 7 cm high, cylindrical, irregularly subdichotomous or corymbose. Internodes vary between 1 to 1.5 cm long.

Locality: Hundred Islands in one islet, attached to coral rock.

GALAXAURA SQUALIDA Kjellman (1900).

Thalli saxicolous, richly branched dichotomously; cylindrical segments, smooth, annulate in upper part below more or less densely covered with rusty brown calcification.

Locality: Hundred Islands and vicinity.

GELIDIUM PULCHELLUM (Turn.) Kützing, prox. Feldman and Hamel.

Compressed axes, and pinnate branching. Color greenish to purplish, 3 to 5 cm high.

Locality: Hundred Islands in one islet, attached to coral rocks. Used as food and good source of agar-agar.

GELIDIELLA ACEROSA (Forsk.) Feldman and Hamel.

Fucus acerosus FORSKÅL (1775) (Red Sea).
Echinocaulon acerosum (Forskål) BÖRGESEN (1932).

Thalli loosely matted or cæspitose, with free parts to 5 cm high, consisting of numerous spreading, semi-erect or arching, non-percurrent, semirigid, cartilaginous and cylindrical axes, irregular branching with smaller branches confined to one side only, hence asymmetrical. Similar size as preceding.

Locality: Hundred Islands. Same use as preceding.

GRACILARIA EUCHEUMOIDES Harvey (1859).

Frond fleshy, flattened and irregular in form resembling to some extent to *Eucheuma* where the species apparently is derived from.

Locality: Hundred Islands and vicinity. Used as food and good source of agar-agar.

GRACILARIA LICHENOIDES (Linn.) Harvey.

Fucus lichenoides Linn.

Frond filiform cylindrical, gradually alternating upward to a fine apex; densely branched in a divaricate manner. Color pale greenish to brownish red.

Locality: Hundred Islands and vicinity. Same use as preceding.

GRACILARIA CRASSA Harvey, ex J. Agardh.

Corallopsis opuntia J. Agardh.

Resembles slightly to *Gracilaria salicornia* (Ag.) Dawson, being fleshy, cylindrical and somewhat bulbous at distal joints and irregularly dichotomously branched.

Locality: Tandoyong Islet, attached to rocky substratum and coral fragments. Good source of agar-agar.

HALYMENIA DILATATA Zanardini (1851) (Massua, Red Sea).

Frond broad flattened measuring 16 cm long by 7 cm wide irregular in shape. Color greenish to reddish. Gelatinous.

Locality: Hundred Islands and vicinity. Same use as preceding.

HALYMENIA FORMOSA Harvey.

Frond finely branched, bushlike, measuring 10 to 20 cm high. Color reddish. Gelatinous.

Locality: Hundred Islands and vicinity. Same use as preceding.

HALYMENIA MACULATA J. Agardh (1885).

Frond broad, flattened and crenulated, gelatinous.

Locality: Hundred Islands on coral fragments and among Alcyonarians.

HYPNEA NIDULANS Setchell.

Thalli large, branch irregularly with coarse texture. Creeping habit over pebbles and coral fragments. Bright red color.

Locality: Hundred Islands and vicinity. Used as food and for agar-agar.

HYPNEA VALENTIÆ (Turn.) Montagne (1840).

Fucus valentiæ Turner.

Hypnea charoides Lamouroux.

Characterized by long slender, lateral ramuli. Agrees with Dawson (1954).

Locality: Hundred Islands and vicinity.

HYPOGLOSSUM ATTENUATUM Gardner.

Small leaflike plants 0.5 to 1.0 cm long attached to coral fragments and alcyonarians. Fronds narrow leaflike attenuated at tip. Distinct midrib and reproductive cells at distal part of blade. Resembles *H. minimum* Yamada to some extent.

Locality: Panakalan Islet, attached to some dead coral fragments and alcyonarians.

JANIA TENELLA var. ZACÆ Dawson.

Thalli epiphytic on *Turbinaria* and other brown algæ. Thalli segmented, dichotomously branched. Intergenicula compressed or flattened throughout. Tufts on host 1.0 to 1.5 cm high.

Locality: Hundred Islands and vicinity.

LAURENCIA PAPILLOSA (Forsk.) Greville (1830).

Fucus papillosus Forsk. (1775) (Red Sea).

Axes percurrent densely covered with short, wartlike lateral or turbinate branchlets. Thallus fleshy, opaque in preserved state.

Locality: Hundred Islands among coral reefs attached to rocks.

LIAGORA DIVARICATA Tseng.

Thalli saxicolous, 2 to 4 cm high, dichotomously branched, whitish to brownish; calcification moderate and heavier at basal portion. Agrees with Dawson's illustration 1954.

Locality: Hundred Islands and vicinity attached to coral fragments.

LIAGORA JAPONICA Yamada (1938).

Thalli saxicolous, 4 to 8 cm high, dichotomously branched, whitish to pale rose in color; calcification moderate and evenly distributed throughout.

Locality: Hundred Islands and vicinity attached to coral fragments.

LIAGORA sp.

Thalli irregularly, dichotomously branched, flattened, 2 to 3 mm wide and the entire plant 4 to 5 cm high, brown in color; calcification slight. Tips of branches blunt and broad.

Locality: Hundred Islands attached to coral fragments.

LITHOPHYLLUM OKAMURAI Foslie (1900).

With few low, domoid carposporic conceptacles. Resembles closely that of Dawson (1954).

Locality: Hundred Islands among coral reefs.

MASTOPHORA ROSEA (C. Ag.) Setch.

Thalli crustose flattened and irregularly dichotomous, some branches trichotomous; 2 to 4 cm high, frond 2 to 3 mm wide, color pinkish violet. With conical cystocarps formed abundantly in ventral side of frond.

Locality: Hundred Islands forming part of fringing reefs in some islets.

MELOBESIA FARINOSA Lamour.

Fronds calcareous orbicular becoming indefinite in outline. Sporangia superficial, hemispheric conical with a single orifice.

Locality: Hundred Islands and vicinity attached to fronds of *Sargassum* cast ashore.

MICROCLADIA GLANDULOSA Grev.

Fronds deep red, cartilaginous and membranaceous, tufted, 2 to 7 cm high, compressed, branched from base, alternate irregularly dichotomous; branches distichous and apices of ramuli bifid and hooked inward. Apparently a new variety.

Locality: Hundred Islands attached to eroded base of an islet and sheltered by the uneroded part.

PEYSSONNELIA CALCEA Heydrich (1897).

Crustose, on coral fragments. Heavily calcified.

Locality: Hundred Islands among coral reef.

POLYSIPHONIA sp.

Attached to coral fragments and Alcyonarians.

Locality: Panakalan and Tandoyong Islets.

PORPYRA CRISPATA Kjellman (1897).

Epiphytic on some phanerogamic plants. Used as food in form of salad.

Locality: Panakalan and Tandoyong Islets.

RHODOPELTIS BOREALIS Yamada.

Resembles *Amphiroa anceps* Lammarck to some extent. Distinctive characters of this species elongato-ancipitous segments mostly 4 to 5 times as long as broad. Thalli dichotomously branched, segments 2 to 3 mm wide.

Locality: Hundred Islands in one of the islets whose base is eroded and well sheltered. Attached to rocky substratum with distinct rhizoid attachment. Natural color reddish or light red and turned white later when exposed for some time.

TITANOPHORA WEBERÆ Börgesen.

Thallus lightly calcified in inner region, complanate, attached by a small disc, with short stipe from which branch primarily, irregularly palmate flabellate fronds, divided into numerous branches distally, forming a ruffled clump, pinkish in color.

Locality: Hundred Islands particularly in fringing reefs of some islets.

TOLYPIOCLADIA CONDENSATA (Weber van Bosse) Silva.

Dark grayish, spongy and irregular frond attached to long blades of *Posidonia* sp.

Locality: Tandoyong and Panakalan Islets.

WURDEMANNIA MINIATA (Lam. and Desc.) Feldman and Hamel (1934).

Gelidium miniatum Kützing.

Fucus miniatus LAMARCK and CANDOLLE (1815) (Mediterranean France).

Wurdemannia setacea Harvey (1853).

Dense mat of slender, tiny branched erect filaments, approximately 2 cm high. Filaments cylindrical, irregularly branched, no apical cell.

Locality: Hundred Islands and vicinity among coral reefs attached to coral fragments.

The above-listed marine vegetation of the Hundred Islands and vicinity represents only a part of the entire phanerogamic and cryptogamic marine forms of the place. The said specimens described in this paper are deposited in the Division of Inland Fisheries, Bureau of Fisheries at Diliman, Quezon City and also at the Graduate School Collection of the University of Sto. Tomas, Manila. Some are also in the collection of the College of Fisheries at Port Area, Manila. Apparently many more have not yet been collected. About a hundred species can be easily reported from the place when thoroughly investigated and worked out. A great number of those that are being reported in this short paper were verified and checked by Dr. E. Yale Dawson, Allan Hancock Foundation, University of Southern California, who was the writer's professor in marine botany.

On April 4, 1953 Dr. Dawson, after his survey of the marine vegetation of Nhatrang Bay, Vietnam, where he reported around 224 species of marine plants, dropped in Manila upon the writer's invitation. Both Dawson and the writer went to the Hundred Islands as guests of Mr. Jose M. Lichauco, then Director of the Hundred Islands National Park. A preliminary survey of the marine vegetation of the place was undertaken. The Tandoyong and Panakalan vicinities were selected to begin with. One afternoon work in a place is hardly enough to determine the richness of the areas, yet in such a short period Dr. Dawson was greatly impressed of the varied number of species encountered. The writer continued the survey, and collection of materials was made a month later for a period

of almost a month. Many interesting forms were collected and sent to Dr. Dawson.

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